Enter and Win, See Page 100

Jupiter's Hot New Color Images

ASTRONOMY®

March 1997 U.S. $3.95
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Can. $5.25

ICD 08070

Seeing Mars through the Ages

Comet Hale-Bopp Takes Center Stage

Great Comet West

For Great Stargazing, Learn to Read the Weather

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LX50

Advanced technology at the most affordable prices *ever.*

■ Battery-Powered, Completely Cordless Operation! Meade LX50 models operate for more than 50 hours from six AA-size batteries inserted through the telescope's control panel. Or use the standard-equipment 25 ft. cord to power the telescope directly from any auto cigarette lighter plug.

■ Standard-Equipment Declination Motor and Hand Controller: Plug the hand controller into the LX50 control panel and you're ready for full dual-axis drive capability at any of 4 photo-guide or microslew speeds: 2x, 8x, 16x, or 32x, plus quartz-controlled sidereal-rate tracking in R.A. Switch speeds instantly using the speed-control button on the hand controller. Dual-axis drive rate is indicated by a red LED.

■ Multi-Function Control Panel: Includes connectors for CCD autoguiders; for the standard-equipment Declination motor; and for the optional Magellan II Computer-Corrector *(below)*. A North-South switch permits telescope operation anywhere in the world.

■ Super Multi-Coated Optics: The exact same EMC super multi-coated optical tube assemblies included with Meade LX200 models.

■ Massive LX200-type Fork Mounts: Meade LX50 mounts are manufactured of the same virgin aluminum castings as Meade LX200 Schmidt-Cassegrains. Massive, rigid mountings that include the Meade LX worm-gear drive system with low periodic error for advanced photographic or CCD imaging applications. *No competing mid-priced equatorial mountings even come close.*

SPECIFICATIONS: 7", 8", and 10" LX50's—Each complete telescope includes 8" or 10" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty LX200-type fork mount; 5.75" LX worm gear system in R.A.; multi-function control panel; DC servo Declination motor; manual and electric slow-motion controls on both axes; setting circles on both axes; keypad hand controller; 4-speed drive controls on both axes; battery compartment accepting six (user-supplied) AA-size batteries; 25 ft. power cord for telescope operation from 12v. auto cigarette lighter plug; 6 x 30mm (7" and 8" models) or 8 x 50mm (10") viewfinder; 1.25" diagonal prism; MA25mm multi-coated eyepiece (1.25"); standard equatorial wedge with elevation scale, bubble level, and azimuth control; complete operating instructions.

8" LX50 Schmidt-Cassegrain	**$1395.**
10" LX50 Schmidt-Cassegrain	**1695.**
7" LX50 Maksutov-Cassegrain	**1795.**
Variable-Height Field Tripod	**295.**
7" Maksutov-Cassegrain Tube Ass'y	**1295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 7"—$125; 7" Tube Assembly—$65.

Meade Magellan™ II Computer-Corrector for LX50 Telescopes: Plug the Magellan II into the control panel of your LX50 and enjoy an incredible range of advanced capabilities. ■ Fast manual slewing to any object, either from input RA and Dec or from the 12,218-object database. ■ High-resolution 4096-pulse encoders (5.3 arc-minute precision), concealed in special LX50 encoder compartments. ■ Large 32-character, red-backlighted display. ■ Quick 2-star alignment. ■ Four-speed (2x, 8x, 16x, 32x sidereal) dual-axis drive corrector/microslewing system.

#2024: Magellan II for LX50's—Includes Magellan II hand controller *(right)*; encoders for both axes; all required mounting hardware. Installs to any LX50 in minutes. **$495.** + $15 packing and shipping in the 48 states.

MEADE
MAGELLAN II
COMPUTER-CORRECTOR
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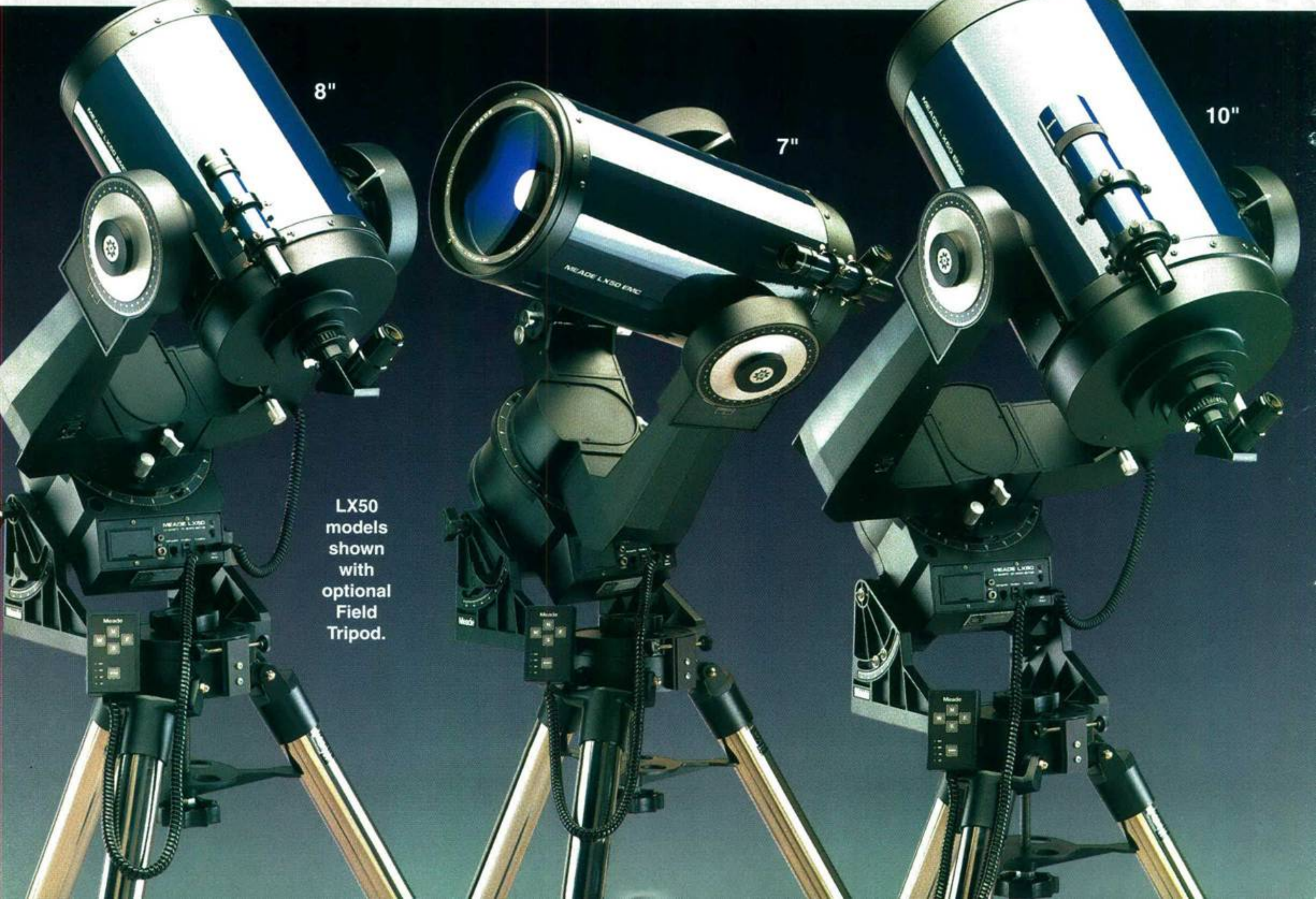
only $495!



LX50 models shown with optional Field Tripod.

The largest-selling serious telescopes in the world.

LX200

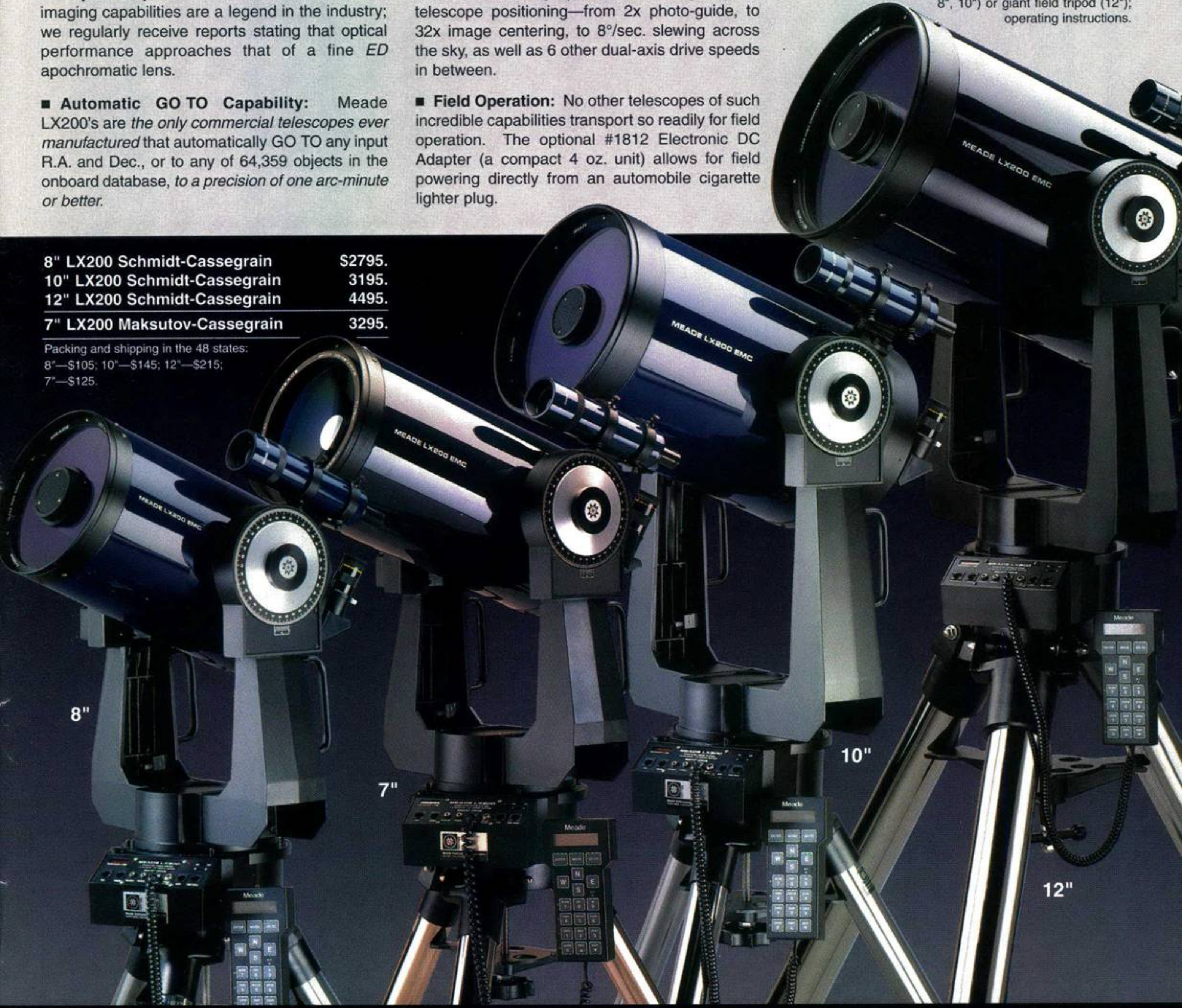
In virtually every country in the world where serious telescopes are sold, more Meade LX200's are sold than all competing models *combined*. Consider these *standard-equipment* specifications:

- **Superb Optics:** LX200 diffraction-limited imaging capabilities are a legend in the industry; we regularly receive reports stating that optical performance approaches that of a fine *ED* apochromatic lens.
- **Automatic GO TO Capability:** Meade LX200's are *the only commercial telescopes ever manufactured* that automatically GO TO any input R.A. and Dec., or to any of 64,359 objects in the onboard database, *to a precision of one arc-minute or better.*
- **Meade LX200 High-Precision Pointing™** is so precise it permits the positioning of *every* selected object on *every* commercially-available CCD chip *every* time, automatically — *a feat that no other telescope priced under $40,000 can accomplish.*
- **Permanently-Programmable Smart Drive™** routinely achieves 5 arc. sec. periodic error, an observatory standard.
- **9-Speed Dual-Axis Electronics:** Electronics that cover every possible contingency of telescope positioning—from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, as well as 6 other dual-axis drive speeds in between.
- **Field Operation:** No other telescopes of such incredible capabilities transport so readily for field operation. The optional #1812 Electronic DC Adapter (a compact 4 oz. unit) allows for field powering directly from an automobile cigarette lighter plug.

SPECIFICATIONS: 7", 8", 10", and 12" LX200's—Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC; 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

8" LX200 Schmidt-Cassegrain	$2795.
10" LX200 Schmidt-Cassegrain	3195.
12" LX200 Schmidt-Cassegrain	4495.
7" LX200 Maksutov-Cassegrain	3295.

Packing and shipping in the 48 states:
8"—$105; 10"—$145; 12"—$215;
7"—$125.



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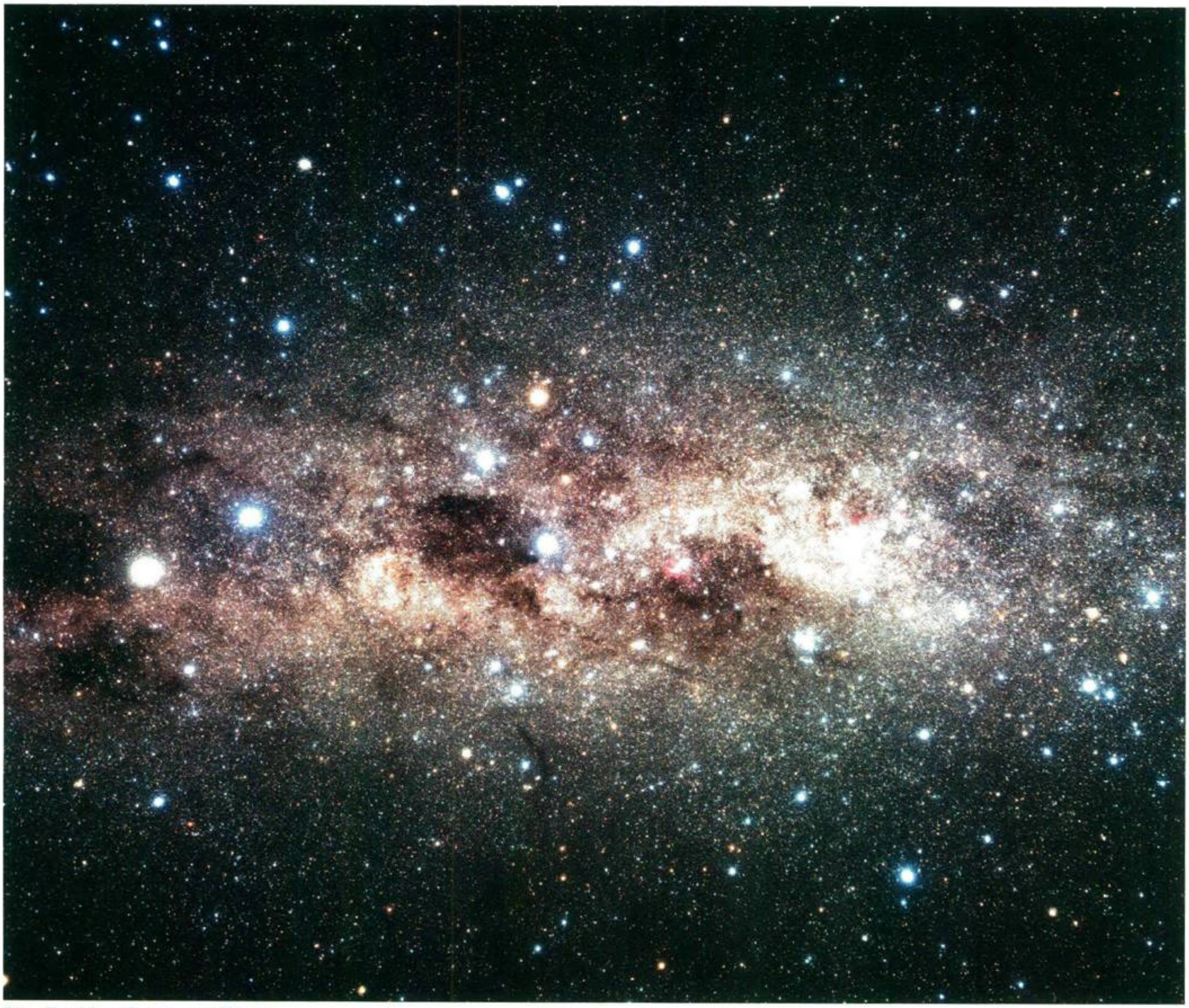

Luke Dodd

38 Probing Our Local Cloud

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Close Encounters of the Comet Kind

Will Hale-Bopp turn out to be the comet of the decade? We'll all find out this month when the comet makes its closest approach to Earth, glows at its brightest, and displays its longest tail. *Alan Hale.*

Cover photo
Ronald E. Royer.

38 Probing Our Local Cloud

A tenuous cloud of gas — the remains of a star that blew up millions of years ago — surrounds the Sun and its family of planets. *Ken Croswell.*

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The spacecraft reveals a magnetic field for Ganymede, possible "stealth plumes" on Io, and a dynamic Great Red Spot on Jupiter. *Richard Talcott.*

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A brilliant comet vies with Mars for evening supremacy, but don't overlook a deep partial eclipse of the Moon. *Martin Ratcliffe and Alister Ling.*

Ralph Wetmore/Tony Stone

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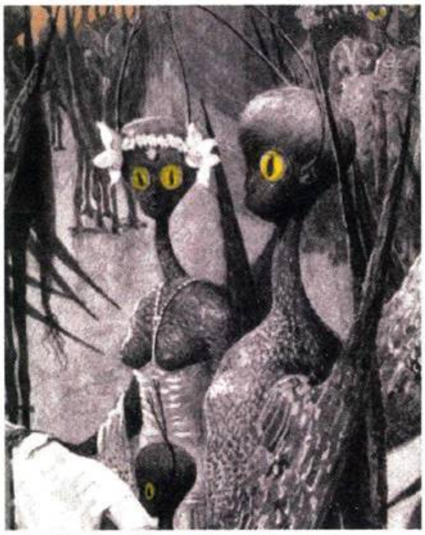
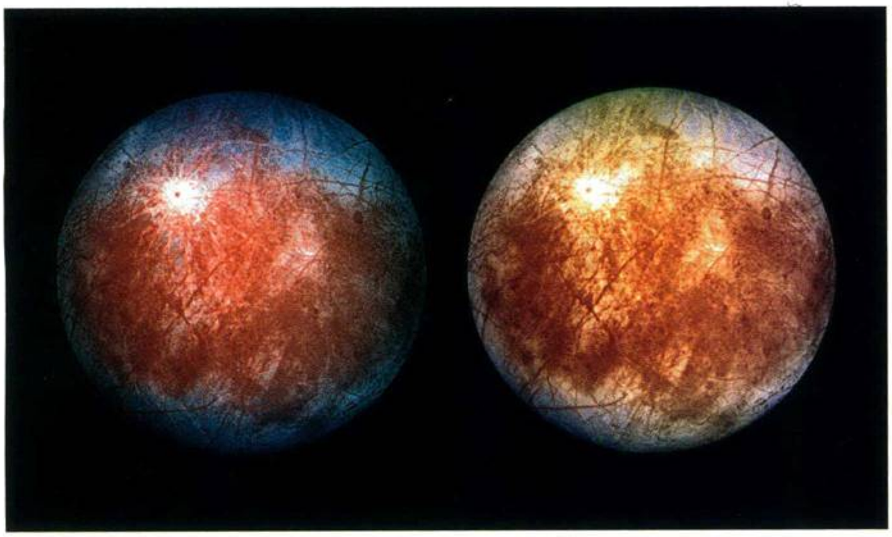

Cosmopolitan

44 Seeing Mars through the Ages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Capturing wonderful images of the comet isn't all that hard, as long as you pick the best film for the job. *Chris Schur.*

80 Peeling Away the Overcast

If you know what to look for, the daily weather forecast can clue you in to how good the night's observing will be. *Vince Condella.*

88 Your Guide to Observing Mars

With the Red Planet looming large, observers will get beautiful views of icy polar caps and dark surface markings. *Murray Paulson.*

92 Truck Your Scope around in Style

This easy-to-build tripod frame will help get you and your telescope outside and ready to observe in no time. *Ed Stewart.*

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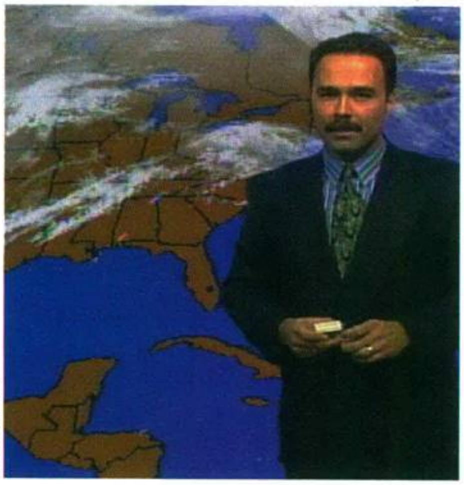
BEHIND THE SCENES

Weathering Wisdom

Last week, someone asked me why television weather segments so often included regular reports on celestial events in the night sky. I didn't say so, but I thought the answer was pretty simple: The sky is the sky, after all. What distinguishes the day sky from night, however, may be deceptively childlike. It recaptures a time in our lives when we thought stars were no farther away than clouds.



Vince Condella

For grown-ups, most salient interpretations of the daytime sky are exceedingly pragmatic. Is the sky clear? Is there rain? Snow? Can we hold the family picnic?

For the child in all of us, the nighttime sky is more significant for its entertainment value. On a clear night, scant light pricks a lacy pattern across a black dome and begs for explanation. We look up and our vision leads us to rich imaginings. That's why every culture on Earth offers a distinct version of what makes the stars and how they got there.

Vince Condella, chief meteorologist at Milwaukee Fox affiliate WITI-TV, has been interested in the sky — both its daytime and nighttime personalities — for as long as he can remember. In "Peeling Away the Overcast" on page 82, he demonstrates what the practical astronomer can learn from studying the weather.

"When I was little and people asked what I wanted to be when I grew up, I'd always say I wanted to be a meteorologist," says Condella, whose hero at age 7 was Chicago weatherman Harry Volkman. "Harry made the weather interesting and taught me to look up and see things for myself during the day. I just kept on looking up at night and grew interested in astronomy too."

Condella's parents bought him a 3-inch refractor, but his cousin, who lived next door, had a better Newtonian reflector that he used most of the time. "We had our own little star parties," he says.

Although Condella forfeited his plans to formally teach meteorology when he joined a TV weather team, he gets to teach his favorite subject every night — to a huge class. You might be able to use his advice.

Bonnie Bilyeu Gordon

Bonnie Bilyeu Gordon

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The Audit Bureau

MEADE 8" LX10

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All the optical performance of Meade 8" LX50 and LX200 Schmidt Cassegrains...for only *$995!*

For the serious amateur astronomer on a more limited budget, or for the more casual observer who nonetheless demands the very finest in optical performance, the Meade 8" LX10 satisfies every requirement. *No other similarly-priced 8" Schmidt-Cassegrain offers such a range of standard features* — or such a range of important options for special applications. *Standard-equipment includes:*

Super Multi-Coated Optical System: The LX10 includes the *exact same* 8" Schmidt-Cassegrain optical tube assembly as more expensive Meade 8" LX50 and LX200 models. Super multi-coatings (not available even as an *option* on competing 8" telescopes) are included with every LX10 optical system, for the highest levels of light transmission and image contrast.

Equatorial Fork Mounting: The relatively light weight, but very stable, LX10 fork mounting provides all of the rigidity required for sensitive high-power applications of the telescope, or for photographic or CCD imaging. Ball bearings on the polar axis complement the precise action of the internal worm gear system.

Cordless, DC-Powered Electronic Motor Drive: A drive system that includes an electronically-regulated DC servo motor for automatic *sidereal-rate* tracking. The drive is powered by four AA-size batteries that fit conveniently through the telescope's control panel; battery life is in excess of 50 hours.

Worm-Gear System: The LX10's 5.75"-diameter worm gear produces extremely smooth, regular motion in R.A., with low periodic error — a periodic error that permits such advanced capabilities as long-exposure astrophotography or CCD imaging.

Hand Controller: Essential for micro-guiding the telescope during long-exposure astrophotography, the LX10's pushbutton hand controller enables precise corrections in R.A. at 2x speed. With the optional electric Declination motor added to the telescope, the hand controller is functional at 2x speeds on both telescope axes. Both the standard-equipment hand controller and the optional electric Declination motor plug into the telescope's control panel.

SPECIFICATIONS: 8" Model LX10 — Includes 8" Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings (D = 203mm; F = 2000mm, f/10); fork mount with setting circles, manual slow-motion controls, and locks on both axes; 5.75" LX worm gear reduction system; sidereal-rate electronically-regulated DC servo motor drive; 4-pushbutton hand controller for 2x speed corrections in R.A.; battery compartment accepting four (user-supplied) AA-size batteries (telescope may also be powered from an auto cigarette lighter plug, using optional 25 ft. cord); 6 x 30mm viewfinder; eyepiece-holder and diagonal prism (1.25"); MA25mm multi-coated eyepiece; standard equatorial wedge with elevation scale, fine elevation control, and 360° azimuth orientation capability; complete operating instructions.
$995. (+ $65 packing & shipping in the 48 states)

LX10 Field Tripod	**195.**
LX10 Electric Declination Motor System	**85.**
#2014 Magellan I Telescope Computer System for LX10, with 12,218-object database	**375.**

The 94-page Meade 1996 General Catalog is available free of charge from Meade Instruments or from authorized Meade dealers. Prices shown are suggested U.S. mail-order prices.

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Meade
DEC MOTOR

Add the optional LX10 Declination Motor for dual-axis corrections at 2x.

Meade 8" LX10
Schmidt-Cassegrain Telescope, shown with standard-equipment equatorial wedge and hand controller and with optional LX10 Field Tripod.

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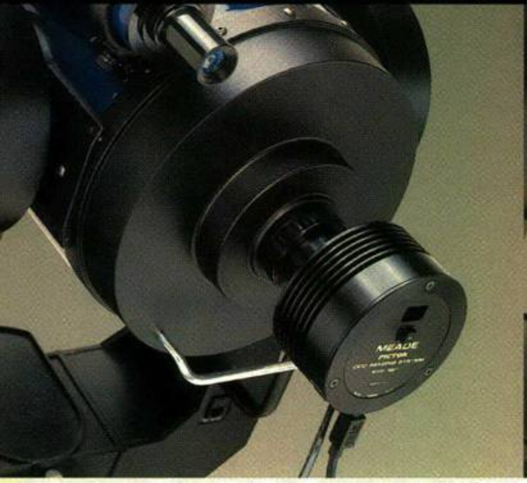
Meade Pictor 208XT
AUTOGUIDER/IMAGER

complete **$495**



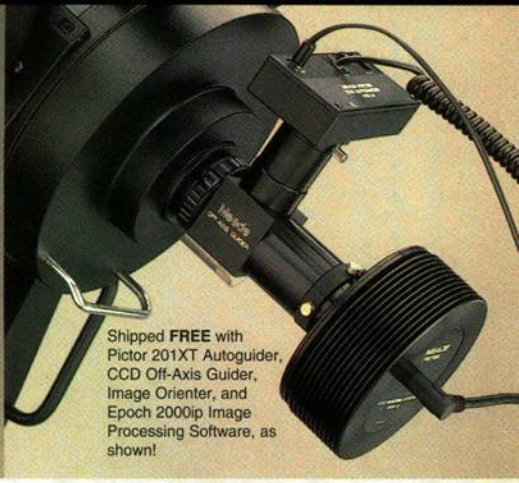
Meade Pictor 216XT
AUTOGUIDER/IMAGER

complete **$695**

Meade Pictor 416XT
AUTOGUIDER/IMAGER

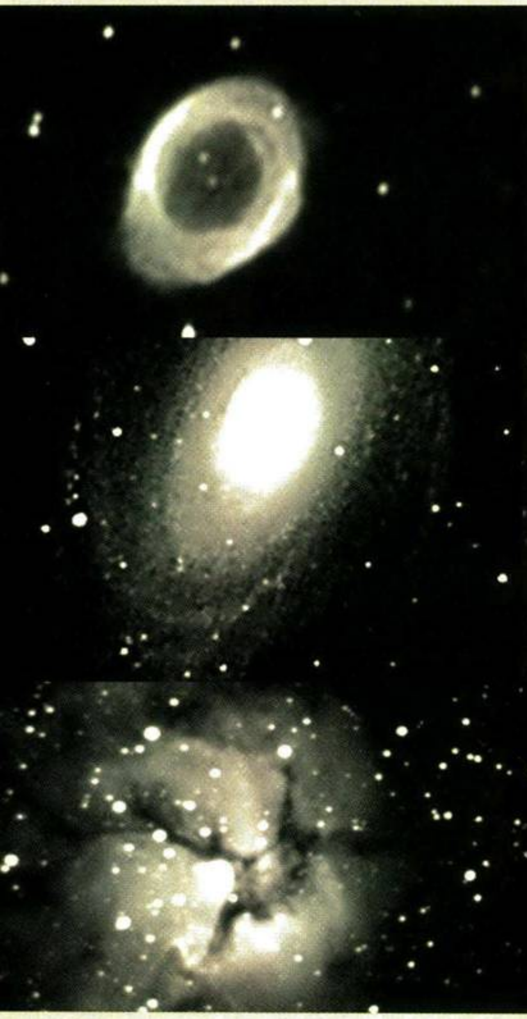
complete **$1695**

includes $800 Meade CCD Equipment System

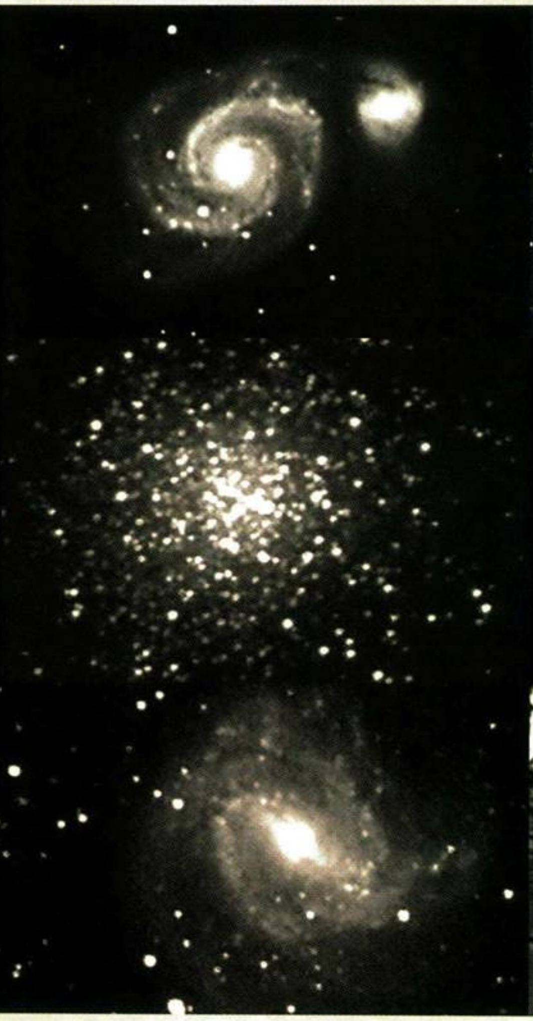


Shipped **FREE** with Pictor 201XT Autoguider, CCD Off-Axis Guider, Image Orienter, and Epoch 2000ip Image Processing Software, as shown!

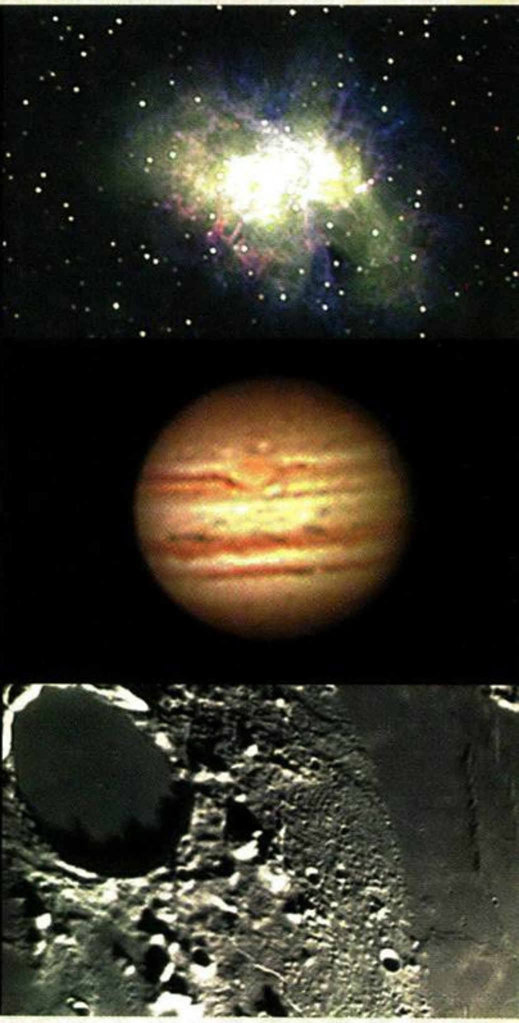
Revolutionary Meade Pictor CCD's are now the world's largest-selling autoguiders and imagers for the amateur astronomer. No other electronic imaging systems offer such an incredible range of capabilities at such amazing price levels. At only **$495** the **Pictor 208XT** produces on the PC display fine, high-resolution 8-bit images *in seconds* of the Moon and planets, or, in 2 or 3 minutes, of thousands of deep-space objects. At **$695** the **Pictor 216XT** enables advanced 16-bit imaging and is *by far* the finest autoguider/imager ever made available at under-$1000. At **$1695** the **Pictor 416XT** permits professional-level imaging capability for the amateur astronomer: an electronic camera capable of producing with amateur telescopes images of the Moon, planets, and deep-space that match or exceed the photographic images obtained with many observatory telescopes. All models are available for immediate shipment. ***For complete information on Meade CCD imaging systems write, call, or fax for your free copy of the 94-page Meade 1997 General Catalog.***



Pictor 208XT images *(top to bottom):* Ring Nebula (M57), 25" reflector, Jack Newton; Galaxy (M81) in Ursa Major, 12" LX200, Scott Roberts; Trifid Nebula (M20), 8" LX200, John Hoot.



Pictor 216XT images: Whirlpool Galaxy (M51), 12" LX200, John Hoot; Globular Cluster (M13), 25" reflector, Jack Newton; Galaxy (M83) in Hydra, 12" LX200, Scott Roberts.



Pictor 416XT images: Crab Nebula (M1), 25" reflector, Jack Newton; Jupiter, 10" LX200 with Stellar Products AO-2 seeing adapter, Dr. Donald Bruns; Moon (crater Plato), 16" f/6 reflector, Dr. Donald Parker.

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MEADE SUPER PLÖSSL
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MEADE ETX

90mm Maksutov-Cassegrain

Meade ETX Astro Telescope. Shown with optional #64 Photo Adapter.

SPECIFICATIONS: ETX Astro Telescope—Includes Maksutov-Cassegrain optical tube assembly (D = 90mm, F = 1250mm, f/13.8) with EMC super multi-coatings; internal flip-mirror system for either straight-through or 90° observing position; equatorial fork mount with slow-motion controls, locks, and setting circles in R.A. and Dec; table tripod with elevation scale on center tripod leg; motor drive system with internal battery compartment accepting three (user-supplied) AA-size batteries; 8 x 21mm achromatic erect-image viewfinder; Series 4000 Super Plössl 26mm eyepiece (1.25"); operating instructions. *Net weight 9 lbs.* **$595***

(+ $20 packing and shipping in the 48 states)

*Suggested U.S. mail-order retail price.

Now you can have diffraction-limited imaging and ultraportability ...at only *$595*, *complete!*

The revolutionary Meade ETX goes anywhere with you at a moment's notice and presents the finest optical images ever made available in an ultraportable telescope.

Optical System: Manufactured at the Meade Irvine, California facility, ETX diffraction-limited optics produce images so high in contrast, brightness, and resolution that the ETX consistently outperforms telescopes of much larger apertures. **Equatorial Fork Mount:** Precise polar alignment in *seconds,* just by extending the center tripod leg to read your latitude on the inscribed scale. **Cordless Motor Drive:** The internal drive system operates from 3 AA-size batteries that power the motor drive for more than 50 hours. A North-South switch permits operation anywhere in the world. **Flip-Mirror System:** Flip the internal optical flat mirror "up" for 90° observing; flip the mirror "down" for terrestrial observing with the optional #932 45° Erecting Prism or for photography with the optional #64 Photo Adapter. **Standard accessories** include a Series 4000 Super Plössl 26mm eyepiece and 8 x 21mm erect-image viewfinder.

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MEADE STARFINDER DOBSONIANS

No other competing Dobsonians include this listing of *standard-equipment* features:

Primary and Secondary Mirrors of Low-Expansion Pyrex® Glass: Unlike the plate glass optics of other Dobsonians that can become thermally unstable, all Meade Dobsonian optics are made of Grade-A fine-annealed Pyrex glass — the exact same professional-quality optics used on Meade Starfinder Equatorials.

Rigid, Durable, Beautiful Dobsonian Mountings, manufactured of cabinet-quality materials, provide extremely smooth motions of the telescope in both altitude and azimuth. Both telescope axes ride on zero-backlash Teflon/Nylon bearings, facilitating the quick location and easy tracking of celestial objects.

Full-Size 1.25" Rack-and-Pinion Focuser: For smooth, precise focusing of the image without wobble or backlash. Focus travel is 2.6"; accepts 1.25" eyepieces.

4-Vane Steel Secondary Mirror System: Permits locked-in support and precise centration and alignment of the secondary mirror.

Multi-Coated MA25mm Eyepiece (1.25"): The Meade Modified Achromatic 25mm eyepiece yields sharp, high-resolution imaging to the field edge.

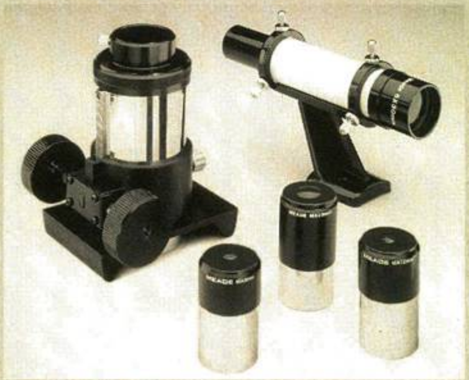
5 x 24mm Viewfinder: Included with all Starfinder Dobsonian models for quick object-location in the main telescope. With crosshair eyepiece and 2-ring bracket.

Optical Tubes: Starfinder Dobsonians include the same strong, spiral-wound Sonotube™ optical tubes used on Starfinder Equatorials *(right)*, tubes with excellent insulating characteristics that reduce internal thermal currents to an absolute minimum.

Performance! *Meade Starfinder Dobsonians and Equatorials are the largest-selling Newtonian reflectors of their apertures in the world.* Every Starfinder model opens up the skies to an extremely wide range of serious visual observing; all 110 Messier objects, thousands of NGC objects — nebulae, galaxies, star clusters, in all their variations of form, color, and extent, as well as the Moon and planets in stunning high-resolution detail. Starfinder Dobsonians are telescopes for visual observing; motor-driven Starfinder Equatorials may be used, in addition, for lunar and planetary photography, and even for limited deep-space photography.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$39; 8"—$49; 10"—$69; 12.5"—$79; 16"—$45 packing, shipped truck freight collect.

Dobsonian Deluxe Accessory Package
only $49.95!



Outfit your Meade Dobsonian with all of the most popular accessories for advanced observing. At the time you order any Dobsonian model, specify the following Deluxe Accessory Package for your telescope, in place of the standard-equipment focuser, viewfinder, and eyepiece, ***for a total of only $49.95 additional:***

1 - **Meade #77 2" Giant Rack-and-Pinion Focuser,** with machined aluminum eyepiece-holders for both 2" and 1.25" eyepieces; includes drawtube lock and 2.6" focuser travel. *(reg. $59.95)*

1 - **Meade #637 6 x 30mm Achromatic Viewfinder,** with wide 7° field; 2-ring metal bracket. *(reg. $49.95)*

3 - **Meade MA9mm, 12mm, and 25mm** multi-coated eyepieces, 1.25" barrel — eyepieces for the full range of lunar, planetary, and deep-space observing. *(reg. $37.95 each)*

Purchased separately, the Deluxe Accessory Package sells for $223.75!

Meade Magellan I Telescope Computer System

Attach the optional Magellan I Telescope Computer System to your Starfinder Dobsonian and finding any of 12,218 celestial objects, or *any* object of known R.A. and Dec., is almost as easy as pointing the telescope! Magellan I's database includes the following objects:

7,840	NGC objects; the complete NGC catalog
4,093	IC objects from the Index Catalog
125	user-defined objects
110	Messier objects; the complete catalog
42	alignment stars for the Magellan system
8	major planets, from Mercury to Pluto
12,218	objects, total

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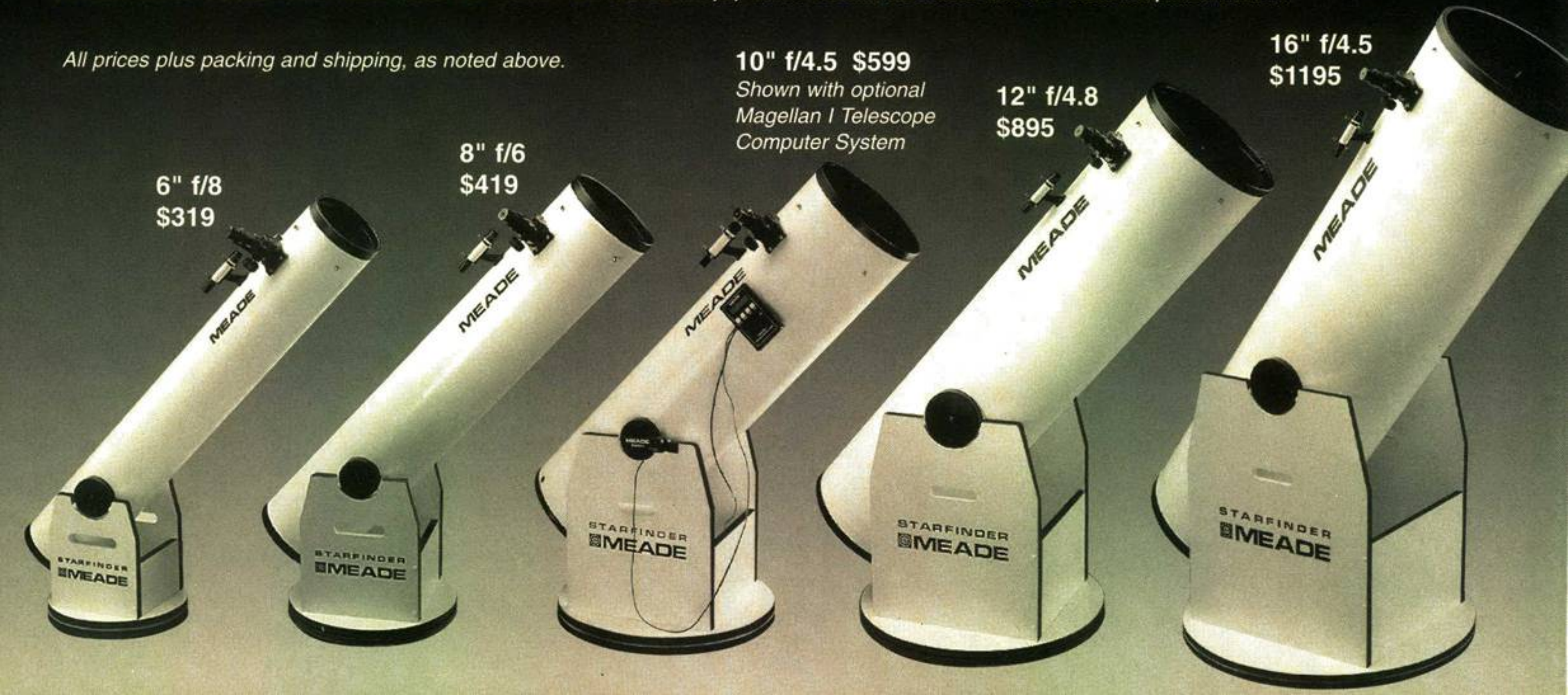
TELESCOPE COMPUTER SYSTEM

Magellan I is supplied *complete* with control/display unit (4" x 5" x 1.25"); premium-grade, high-resolution encoders for each telescope axis (encoder precision is 5.3 arc minutes); RS-232 serial interface; bracket for placement of the controller on the telescope tube; and attachment hardware. Just add the user-supplied 9v. transistor radio battery, and Magellan I is ready to use. First-time installation is quick and simple.

#2010: for Meade Starfinder Dobsonian
6", 8", 10", 12.5", or 16" . . . . $295.
Packing & shipping in the 48 states—$15.

STARFINDER DOBSONIAN TELESCOPES ***Shown with standard-equipment 5 x 24mm viewfinder and 1.25" rack-and-pinion focuser.***

All prices plus packing and shipping, as noted above.



6" f/8
$319

8" f/6
$419

10" f/4.5 $599
Shown with optional Magellan I Telescope Computer System

12" f/4.8
$895

16" f/4.5
$1195

MEADE STARFINDER EQUATORIALS

DC-powered drive systems for fully automatic tracking, and a wide range of standard-equipment features:

Professional-Grade Optical System: Includes hand-figured, parabolic primary mirror and elliptical flat secondary, both of Grade-A Pyrex glass. Optics are multi-coated and meet the theoretical limits of resolution.

Precision Equatorial Mount: Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs for rock-solid support of the optical tube. Moves effortlessly from object to object on precision bearing surfaces. Polar and Dec. shafts are 1" solid steel. Setting circles on both axes.

Battery-Powered Cordless Drive System! Provides fully automatic tracking of celestial objects. Operates for more than 50 hours from 6 (user-supplied) AA-size batteries. Control panel also permits powering the telescope from 12v. auto cigarette lighter plug, using optional 25 ft. cord.

2" Giant Focuser: Meade #77 2" giant rack-and-pinion focuser is included as standard equipment, with eyepiece-holders for both 2" and 1.25" eyepieces.

Accessories and Components: #637 6 x 30mm viewfinder with wide 7° field; multi-coated MA25mm eyepiece (1.25"); strong, durable, spiral-wound optical tube with attractive white finish.

Starfinder Equatorial 16: Includes equatorial mounting with 1.5" steel shafts, Sealmaster ball bearings, 6" dia. pier, and 6 x AA-size battery-powered worm gear drive; 8 x 50mm viewfinder; #77 2" giant focuser.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$65; 8"—$75; 10"—$90; 16"—$55 packing, shipped truck freight collect.

Meade Magellan Telescope Computer Systems

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Magellan I: Use the Magellan I computer to manually slew the telescope quickly to any of 12,218 database objects, or to any object of known R.A. and Dec. Specifications and object database are identical to Magellan I for Starfinder Dobsonians *(see facing page)*.

#2011: for Meade (DC-powered) Starfinder Equatorial 6", 8", or 10" .... $295.
#2012: for Meade (DC-powered) Starfinder Equatorial 16" .... 295.

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Magellan II Computer-Corrector: Plug the Magellan II into the control panel of your Meade Starfinder Equatorial and you have all the capabilities of the Magellan I, above, including 12,218-object database, *plus* a 4-speed (2x, 8x, 16x, 32x), dual-axis, drive corrector/microslewing system.

#2018: for (DC-powered) Starfinder Equatorial 6", 8", 10" .. 495.
#2019: for (DC-powered) Starfinder Equatorial 16" .... 595.

Packing & shipping in the 48 states: Magellan I–$15, Magellan II–$20.

Special Eyepiece Offer! At the time you order any Meade Starfinder Equatorial telescope, you can buy 2 additional multi-coated eyepieces, MA9mm and 12mm, ***for a total of $29.95!*** *Purchased separately, the 2 eyepieces sell for $75.90.*

The fullest exposition of Meade astronomical telescopes, CCD imagers, and telescope accessories is contained in the 94-page Meade 1997 General Catalog.

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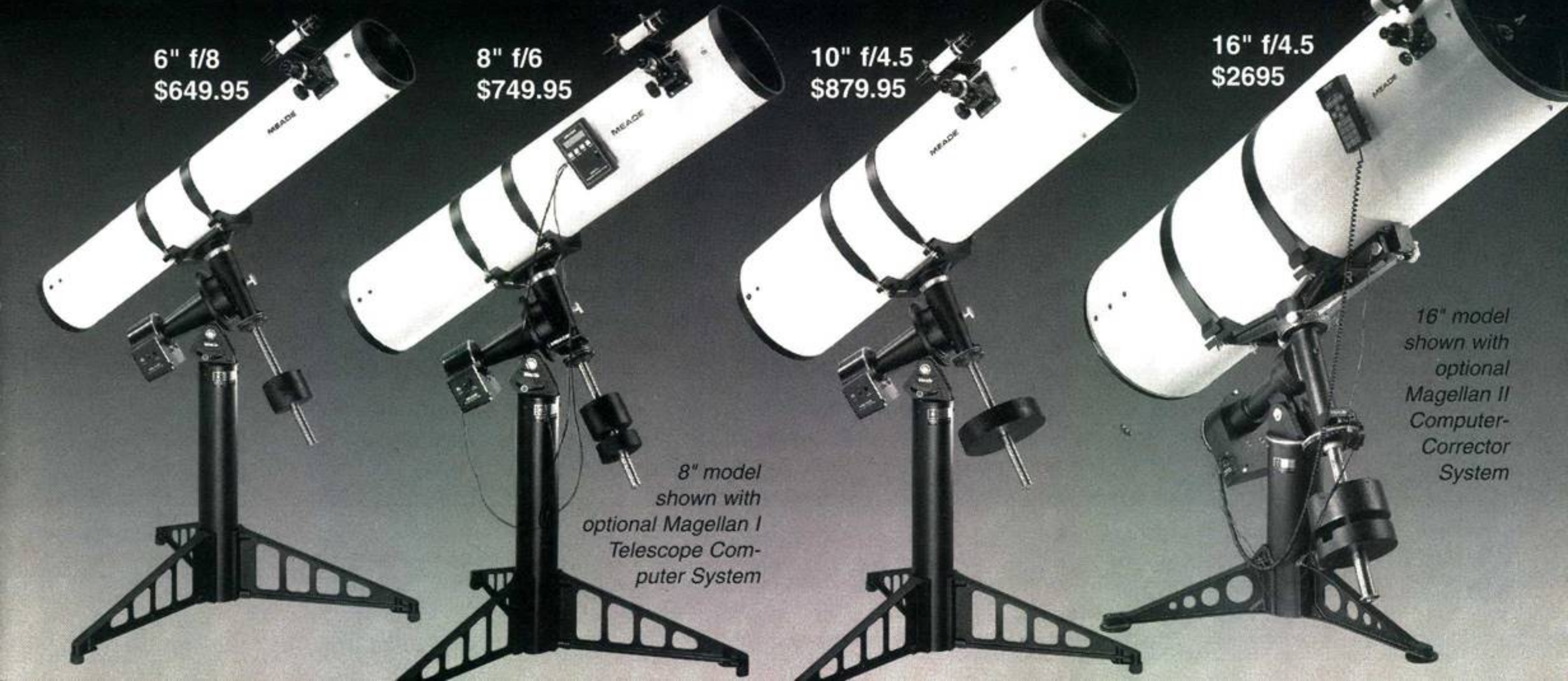
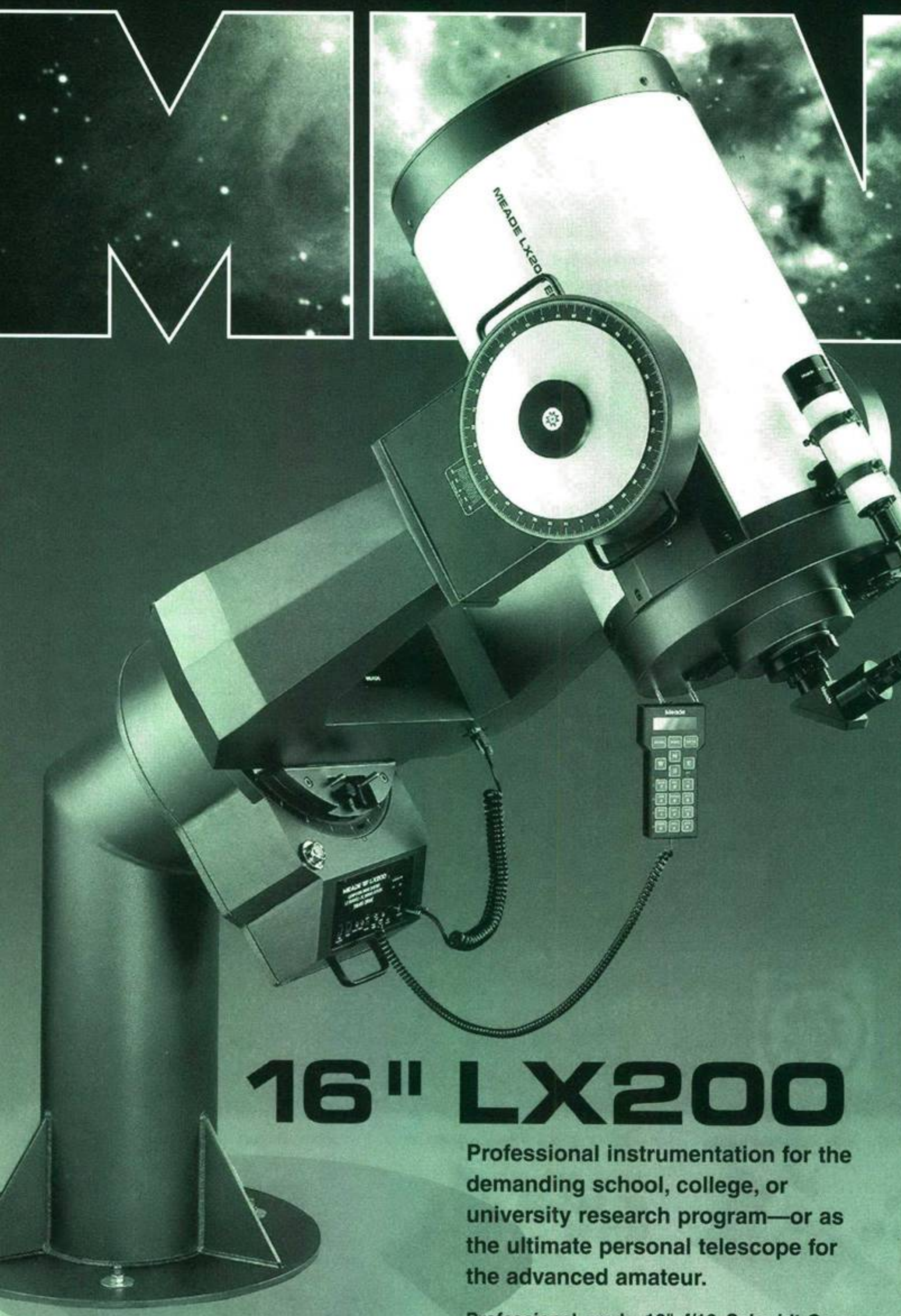
STARFINDER EQUATORIAL TELESCOPES ***Shown with standard-equipment 6 x 30mm or 8 x 50mm viewfinder and 2" giant focuser.***



8" model shown with optional Magellan I Telescope Computer System

16" model shown with optional Magellan II Computer-Corrector System



16" LX200

Professional instrumentation for the demanding school, college, or university research program—or as the ultimate personal telescope for the advanced amateur.

Professional-grade 16" f/10 Schmidt-Cassegrain optical system meets or exceeds advanced requirements; includes BK7 correcting plate with EMC super multi-coatings for high UV transmission. ■ **Massive one-piece fork mount** permits substantial auxiliary equipment to be piggybacked with rock-solid stability. ■ **Large 11" worm gears** on both axes, with factory-programmed Smart Drive™; periodic error less than 5 arc seconds. ■ **Automatic GO TO capability** to any object in the onboard 64,359-object database or to any input R.A. and Dec. ■ **High-Precision Pointing™** to within one arc-minute in the GO TO mode. ■ **DC servo drive systems** with integrated encoders and planetary gearboxes; encoder resolution: 0.13 arc secs. ■ **Six pushbutton-controlled drive-speed rates**, from photo-guide to fast-slew on both axes, simultaneously. ■ **Microprocessor controlled sidereal-rate tracking** in AZ or EQ modes with quartz accuracy. ■ **Home-Pulse Acquisition** permitting remote alignment and operation through a modem link to the telescope's RS-232 interface. ■ **Control panel connectors** for optional systems including CCD autoguiders and imagers, electric focuser, and the Meade **#1222 Field De-rotater** for long-exposure astrophotography in the AZ mode. ■ Available with **supergiant transportable field tripod** (2-person field set-up in less than 10 minutes); **permanent altazimuth pier** (permitting the entire instrument to be housed in a 2-meter dome); or **permanent equatorial pier** (in cases where piggybacked astrocameras do not permit field de-rotation).

Meade 16" LX200 Schmidt-Cassegrain, with Supergiant Transportable Field Tripod.

Write, call, or fax Meade Instruments for your free copy of the 94-page Meade 1997 General Catalog, with complete information on more than 40 Meade telescope models.

The Meade 16" LX200 is in continuous production at the Meade Irvine, Calif. factory. **Delivery time:** 4 to 12 weeks. **Price:** $14,950, complete with supergiant field tripod, plus $385 packing and shipping in the 48 states; prices slightly higher with permanent altazimuth or equatorial pier.

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MEADE
EYEPIECES AND ACCESSORIES

Series 4000™ Super Plössls
52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm	each:	**$79.95** (3.45)
32mm (52°); **40mm** (44°)	each:	**99.95** (3.79)
56mm (52°; 2")		**199.95** (5.48)

Series 4000™ Ultra Wide Angle 84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (3.94); **6.7mm: 199.95** (3.94); **8.8mm** (1.25"/2"): **239.95** (5.87); **14mm** (1.25"/2"): **299.95** (6.28)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture.

$129.95 (3.60)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (3.45)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (3.45)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (3.45)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

#929 or **#930**, each: **$99.95** (5.87)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.45)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (3.45)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (3.45)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue each **$14.95** (2.29)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (2.98)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (2.98)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (2.98)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.29)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (4.27)

Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (3.45)

MA12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Wireless red LED illuminator and variable brightness control. 1.25" **Batteries included.** **$99.95** (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (3.45)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": $27.95; **1.25": $29.95** (2.98)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (2.98)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (2.98)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (2.98)

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (4.27)

Series 4000™ Super Wide Angle 67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (3.94); **18mm: 149.95** (3.94); **24.5mm: 179.95** (4.68); **32mm** (2"): **239.95** (5.87); **40mm** (2"): **299.95** (6.28)

Series 3000™ Plössls 50° field; multi-coated

The very latest in eyepieces from Meade optical designers, new Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Available in a wide range of focal lengths from 5mm through 25mm. All five eyepieces are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. Manufactured exclusively for Meade Instruments by one of Japan's leading lensmakers, Series 3000 Plössls produce fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)
5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.45)

#911B
#910B
#908B
#911N
#910N
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (3.45)
#910B–Threads into 2" eyepieces, 44mm dia.	**119.95** (3.85)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (3.94)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (3.45)
#910N–Threads into 2" eyepieces, 44mm dia.	**129.95** (3.85)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (3.94)

Series 3000™ Plössl 40mm 44°

An excellent complement to the Series 3000 Plössls above, this all-new Plössl 40mm produces spectacular low-power, wide-field results with any telescope. Includes classical 4-element Plössl optics, **multi-coated.** Barrel dia. 1.25"; threaded for filters. Apparent field: 44°.

$79.95 (3.79)

HOW TO ORDER

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■ Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in ( ) next to each price.

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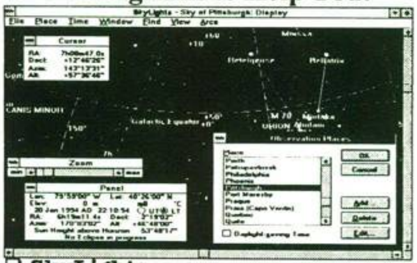
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David even decided to increase the number of ads they are going to run this year. "We can afford to run more ads now because of the high response rate we've been getting," he explains. "It is because of this, and the fact that ASTRONOMY always goes above and beyond to help me with my advertising needs, that we have decided to now run our ads exclusively in ASTRONOMY Magazine."

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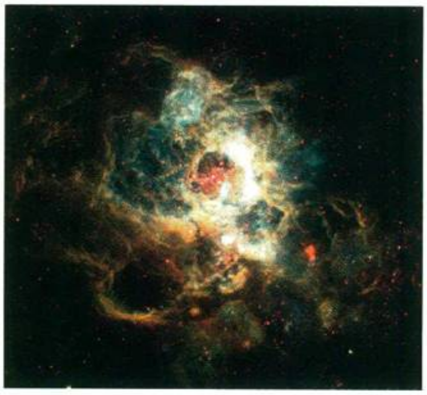

Hui Yang, Jeff J. Hester, and NASA

The Ghoul Nebula?

When I showed my wife Valerie the awesome Hubble image of NGC 604, she tried to put a common name to it, thinking I was showing her an object that ought to be familiar.

"That looks like a ghoul, with the two eye sockets on the right and the gaping mouth to the lower left, and the wire-like hair all around!" she exclaimed. I can't help seeing it that way now, and it doesn't lessen the impact of the image. Now, how long will it take for this to end up in the tabloids — "Space Telescope Takes Picture of Living Dead?" — *Alister Ling, Edmonton, Alberta*

Killer Galaxy Too Violent

"Our Killer Galaxy's Violent Past?!" (December 1996)? What kind of Christmas issue is this? I was even more dismayed to hear benevolence dismissed as "romanticism" and the real world described as chiefly consisting of death and danger. Granted, there is too much of both, but they are not the only story. Without even a future "peaceable kingdom" to look forward to, we would indeed be a forlorn race of beings! — *David Moody, Ulster Park, New York*

I truly enjoy ASTRONOMY, which I read avidly every month, but my deep European humanistic roots force me to object to a side-issue in "Behind the Scenes" (December 1996): Romanticism was the offspring of the German "Sturm und Drang," of the Ossianic poets of Britain. They regarded Nature as hostile to mankind.

The pastoral, bucolic English

scenes you are referring to (Beethoven's Sixth, in music) are typical of the diametrically opposed Neo-Classicism, which preceded Romanticism and was actually so opposed by the younger generation of the early 19th century as to trigger the birth of Romanticism as opposing philosophy.

Existentialism, in its claims that human life is meaningless, Nature is an enemy, and Nothing is the only real essence of the World, is another expression of decadent Romanticism of the present century. So, the "Killer Galaxy" is actually a very Romantic being, and you should have talked of "Neo-Classicism" instead.

Please accept this minor reproach from an old-fashioned European Humanistic Scientist, if such a being can truly exist. — *Massimo Fischetti, Yorktown Heights, New York*

Welfare vs. Space Exploration?

I am compelled to address the concerns of Kassandra Mullan's letter (November 1996) that expressed her upset at the government's decision to cut back on extrasolar planetary research. Cost benefit analyses often determine whether a particular program is necessary. There must be a sound justification for the program and a clear benefit to the people. Most citizens do not understand or care for space exploration and do not view space exploration to be as important as does Ms. Mullan.

If the scientific community is to deal effectively with these cuts, it must begin to find ways to interest or involve the American public in the astrophysical sciences. Programs such as welfare and immigration reform compete. Ms. Mullan and her colleagues must find new ways to market the importance of space exploration to people. Only then can change occur. — *Thomas V. Panzone, Queens, New York*

Preparing to Go Deep

My six-year-old daughter, Kate, and I have been inspired to get deeper into astronomy. I've been a binocular observer for years and have never lost a sense of wonder

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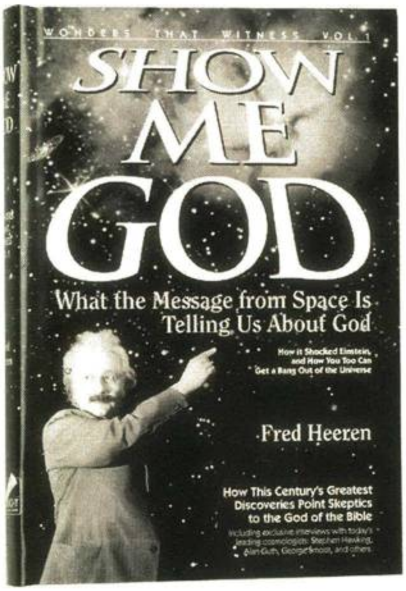
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when I look at a clear sky similar to that which enthralled the many visitors at the Grand Canyon ("Observing at the Edge," October 1996). For the September lunar eclipse, a group from work got together with families, binoculars, and small telescopes. In addition to observing the eclipse, we looked at many different celestial objects. When the group found the Andromeda Galaxy, a hush settled over the crowd.

Rather than universally ignoring small scopes, beginners could have fun and begin to share the magic with others if they get a small scope while they're waiting to afford the "big one."

It will be a while yet before I get my big telescope. In the meantime, I'll get lots of quality time learning and sharing the fun with Kate. Sure, I could have saved the money to dive in deep, but I'd miss all this fun. — *Bob Hillery, Chesapeake, Virginia*

Martian News Hard to Find

When I first heard the news about the possibility of microbes in the martian meteorite, I was very excited. I kept the *Tampa Tribune* headline and saved it. But when I went to look for the story in *Newsweek*, or any other magazine, I was disappointed because I could not find it anywhere. Eventually, I found a *Time* magazine with an article, but the front cover had a picture of Bob Dole, and just a small picture with a caption about the martian discovery.

Finally, ASTRONOMY satisfied me with treating the discovery like it was possibly the biggest news in human history.

I will keep the November issue of ASTRONOMY for a lifetime. — *James Vincent, Tampa, Florida*

Popular Opinion but No Facts

I wonder if the letters you published in response to Robert Naeye's "OK, Where Are They?" (October 1996) were the best of the 1,200 you received. I would be interested to read any valid information or even a well-founded opinion that might strengthen or weaken Mr. Naeye's statements. Instead, what I read is popular opinion with no factual basis. These writers speak as if they have knowledge but they are really making the grand assumption that because intelligent life exists here, it must exist elsewhere. There is not even the least attempt to counteract any of Mr. Naeye's compelling evidence to the contrary.

However, Frank Rose's approach appears to be a fair evaluation of what might be reality and what is consistent with the observable evidence. — *Bob Chaffee, Ithaca, New York*

Hale-Bopp Naked Eye!

On a cold, clear visit to Addison, Vermont, all in our party were astounded by the number of stars and objects visible to the naked eye.

By following the articles and sky charts in ASTRONOMY, we had no trouble finding Comet Hale-Bopp with the naked eye although a pair of inexpensive binoculars made the view spectacular, tail and all. — *Paul A. Kruger, Hillsborough, New Jersey*

Shuttle Re-entry Picture Perfect

I watched the re-entry pass of the shuttle Atlantis over Calgary on September 26, 1996. Incredible! The bright orange light from the shuttle appeared near the western horizon in the same part of the sky as the Moon, then passed almost directly overhead and very close to Venus. It then dropped into the eastern horizon leaving an easily visible trail looking much like a contrail all the way across the sky. It was an unmistakable sight easily visible to anyone willing to drag out of bed and look up. A few minutes after the shuttle disappeared over the horizon, I heard a distinct "pop" as the sonic boom reached the ground.

What a stroke of luck to have everything go right. — *Sid Lee, Calgary, Alberta* □

ASTRONOMY welcomes feedback. Send it to ASTRONOMY Letters, P.O. Box 1612, Waukesha, WI 53187, or on the Internet, use letters@astronomy.com. Letters may be edited for space and clarity.

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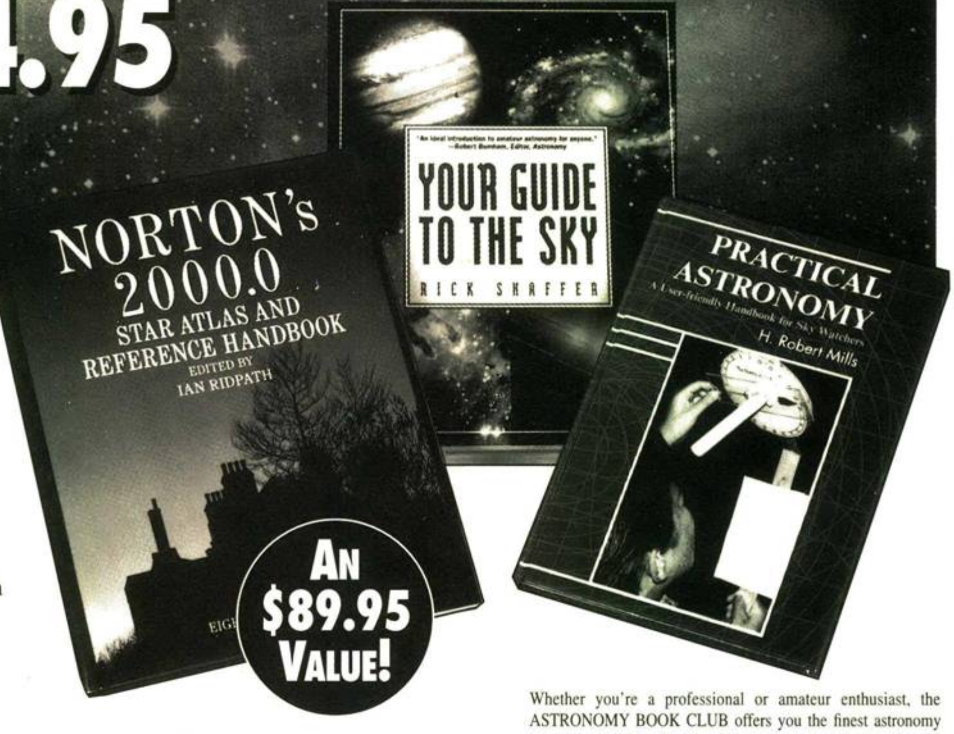

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Earth, Wind, Fire, and Stars

Sheldon Reynolds views and photographs the heavens when he's not recording or touring with the R & B band Earth, Wind, and Fire. The 34-year-old guitarist and vocalist joined EWF in 1988 after spending five years with The Commodores. ASTRONOMY's John Shibley caught up with Reynolds shortly before his band left on a Far East tour.

Great Scott Productions

Earth, Wind, and Fire band members, clockwise from top left: Verdine White, Sheldon Reynolds, Maurice White, Sonny Emory, Ralph Johnson, and Philip Bailey.

Where did your interest in astronomy start?

As a small kid I lived in the city, but then we moved out into a suburb of Cincinnati when I was 12. It was very dark out there. That was when I first saw the stars. I think by the time I was in my teens I really got into being outside to enjoy the peace and beauty of space.

For the next 20 years my astronomy interest coasted through my music career. I really got into it again once I started playing in bands and traveling. I was in Hawaii with the Commodores for about a week. There were all these stars and constellations I'd never seen before, a lot of stuff in the south. I was awed. That's when I said "Hey, I need some binoculars to get back into this!"

Did it take a lot of courage for a 12-year-old to take that first step into the dark?

The suburbs at night were different from what I was used to. City life was one thing — you heard gunshots and police flying by — those were just sound effects you filtered out after a while. So when we moved out into the suburbs, it was peace and quiet, and this night sky. Every city kid should experience it.

One night I had to walk around into a back alley in the shadows to take the garbage out. It was getting dark and the stars were just coming out. I'd never seen so many of them. Suddenly I glanced down toward the garbage can and saw two burning, red eyes looking back at me. My 12-year-old mind saw a demon.

I waited to see if the eyes moved. They moved, and it was a red dog. Well, I'd never seen a *red* dog! I figured it was a demon dog . . . a dog from hell! That was enough, beautiful sky or not, I was out of there. It took me a week to realize we had a neighborhood fox, something city kids only see in zoos. But not standing out in the backyard.

So that's how I discovered the sky and foxes — by taking out the garbage to a dark alley.

What's the coolest experience you've had doing astronomy?

The neatest thing I've seen was when the band was traveling between gigs by bus between Salt Lake City and Denver. We were 100 miles from nowhere, in the middle of the night. This bus driver stopped to stretch. Another band member and I got off the bus too. I was teaching him about astronomy, and was going to impress him with all my knowledge. Suddenly I couldn't find my way around the sky. There were too many stars! You could see the glow of the Milky Way. Ever since then, I've had a number of band members join me for a view through the binoculars.

How do we get more people turned onto astronomy?

The simpler you talk about astronomy, the more interested people get. Set up in a yard with your neighbors. Try to relate to them in a way they can understand. The universe is so far removed from regular experiences, you must make it simple. Give them a feel for the scale of the universe. It blows their minds.

Once I asked a guy if he's ever flown before. "No," he said. Yes you have, I said. Ever since you've been on Earth, you've been flying.

What's the most interesting observing session you've had?

One night I went out by myself to a park, and this car pulls up full of young boys, about 100 yards away. Four of them get out of the car, and I can see they're gangbangers. They all belonged to the same gang; the bandannas around the head . . . I could smell the marijuana. And I'm thinking, are they coming to admire or are we going to have a confronta-

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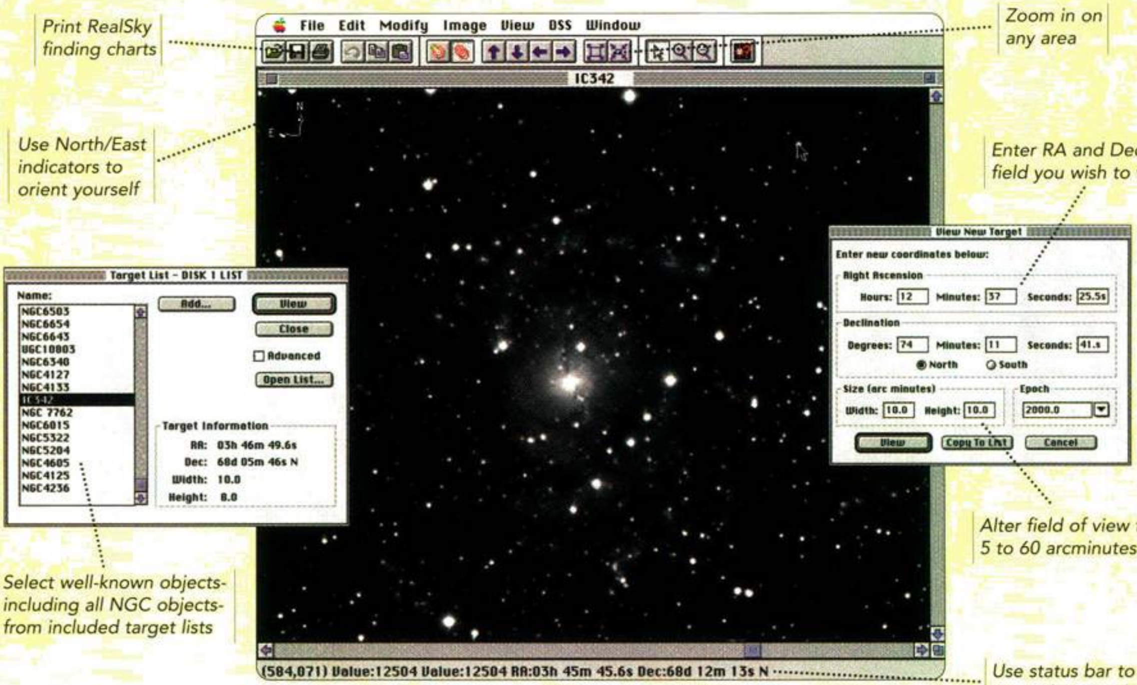

Name:
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Target Information
RA: 03h 46m 49.6s
Dec: 68d 05m 46s N
Width: 10.0
Height: 8.0

Enter new coordinates below:

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Declination
Degrees: 74 Minutes: 11 Seconds: 41.s
● North ○ South

Size (arc minutes)
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WRITE NO. 81 ON THE READER SERVICE CARD

Marie Reynolds

tion here? I'm standing behind my scope in an adrenaline rush, going into some Bruce Lee position. They see this and say, "Hey man, its OK!" They were more scared of me.

I got more than a lesson in astronomy out of these four guys. They were actually very intelligent cats, telling me the difference between Jupiter and Saturn. Each one of them was a would-be scientist. They were just trying to imitate the vibes of their culture, and I had misjudged them. We've got to get past first impressions and prejudices if we're ever going to reach one another.

This applies to astronomy or anything else in life.

Has astronomy influenced your music?

I think one influences the other. Astronomy and music tap into the same part of the mind. Music is abstract. You can't see it. You go off of something you feel. It's mysterious, but it's there and you hear it.

Astronomy has things you can see, but it creates the same sort of wonder that touches your soul. Both music and astronomy provide almost religious experiences for me. Humans have gifts for enjoying music and appreciating the universe, unlike any other creature on Earth. Something wonderful has happened to put us all here and experience this. I've felt God under the sky. I've felt vibes that have said "Everything you see is Me."

As far as I'm concerned, astronomy and music have made my life whole, and I want to share both with anyone who will listen. □

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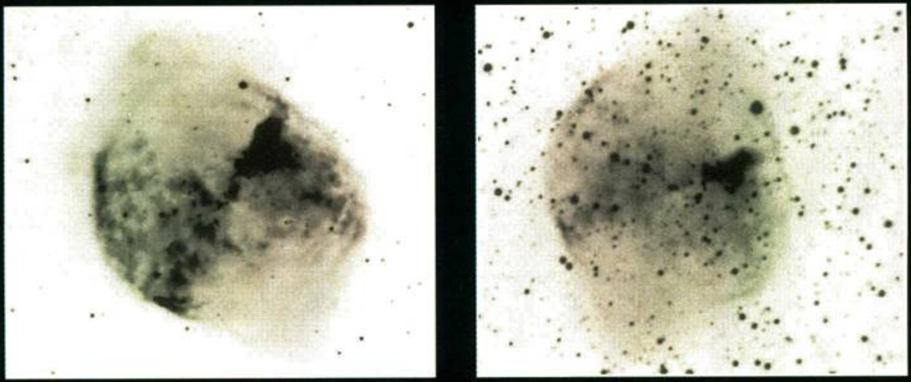

M27 Planetary Nebula. The large apparent size of this nebula classes it as probably one of the nearest of the planetaries at a probable distance of about 850 light years and about 2 1/2 light years in diameter. The central star, of magnitude 13.5, has about 1/2 the solar luminosity, if the adopted distance is reasonably correct. As in all planetary nebulae, the faint central star is an abnormally hot bluish dwarf or sub-dwarf with a spectrum resembling that of an ancient nova and a calculated surface temperature of about 85,000 deg. K, one of the hottest stars known. It is assumed that planetaries are formed by ejection of material from the hot central star, but the exact details of the process are unknown. ***The left image*** is a narrow band 3600 second CCD image taken with a Model ST-7 CCD Imaging Camera through an Ha filter. *Courtesy Benoit Schillings*. ***The right image*** is a 1200 second ST-7 CCD image taken through a 7", f/7 Astrophysics refractor. Both images utilized the self guiding mode. *Courtesy Tony Hallas.*

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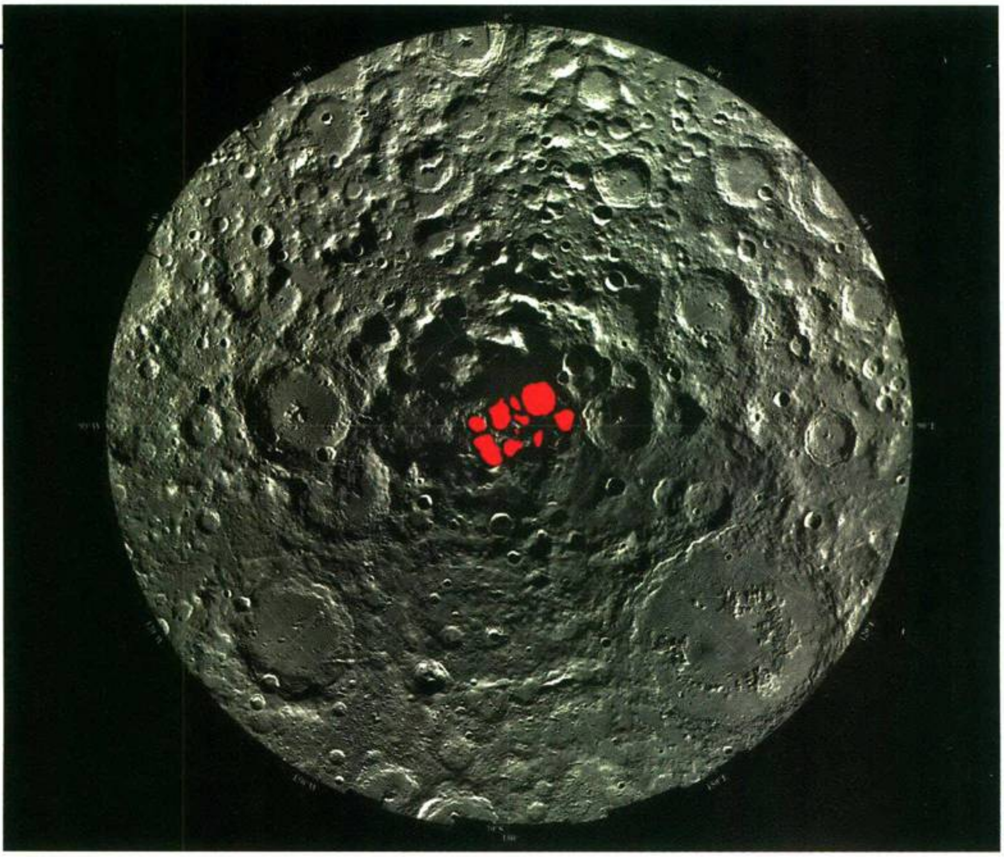
Clementine's Icy Moon



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Red blobs show where reflected radio signals from Clementine betrayed the presence of ice on the Moon. Such ice has the stuff needed to make rocket fuel. Note the perpetually sunlit mountain, just upper right of center, in this mosaic made from Clementine photos. Its oasis of sunlight could support a solar-powered colony that makes rocket fuel from ice buried in the surrounding, darkened craters. "You may be looking at the most valuable piece of real estate in the solar system," says planetary geologist Paul Spudis.

It's not quite a speedskater's dream come true, but scientists now say the Moon's south pole has enough ice to fill a moderately sized lake. The finding comes courtesy of the Department of Defense's Clementine spacecraft. DoD launched the craft in January 1994 to evaluate state-of-the-art imaging sensors. Planetary scientists tagged along when planners used our Moon to test those sensors. Clementine's two-month orbital mission returned close to 1.8 million images that have been used to construct the best map yet of our satellite's surface.

But Clementine's icy discovery didn't involve picture-taking. Using the craft's communications dish like a flashlight, controllers beamed radio signals into regions around the Moon's poles where ice might lurk. They then used radio dishes on Earth to look for reflections, like you would look for light bouncing back from a roadside reflector bathed in headlights.

To their delight, the south pole of the Moon returned telltale radio reflections of water ice mixed with lunar soil. Analysis shows the ice extends down to a depth of 50 feet within an area of 40 square miles. All told, the region contains at least a quarter cubic mile of ice inside craters shrouded in eternal darkness.

But how did ice get there in the first place? Rocks brought back by Apollo tell us the Moon itself is dry. So the notion that water outgassed from the Moon doesn't hold water. The answer might lie with comets — thousands of them have hit the Moon over the last 3 billion years.

"A comet hit releases a water vapor cloud that hangs around the Moon," said Paul Spudis of the Lunar and Planetary Institute at a November press conference announcing Clementine's finding. "If any of the vapor settles into a cold trap, which on the Moon is only 40° C above absolute zero, it can't get out. So over 3 billion years, we've accumulated a significant amount of water ice in this dark area from a number of comet impacts."

This discovery has ramifications for lunar exploration and exploitation. "For the first time on the Moon, we have a preserved record of the rate of cometary impacts over time," says Spudis. "So we can study this deposit and actually understand how the flux of comets in our area of the solar system changed with time."

Polar ice might also support a lunar colony that produces fuel for expeditions into the solar system. Colonists could separate water into liquid oxygen and liquid hydrogen, the same fuel used to power the space shuttle.

"The only difference," says Clementine scientist Stuart Nozette, "is that this fuel is on the Moon to begin with. We don't have to truck it up from Earth."

How to Turn on a Quasar

New Hubble images of a couple dozen quasars show they exist in a striking diversity of galaxies, many of which are colliding violently. This suggests that a variety of mechanisms — some quite subtle — may be responsible for "turning on" quasars, the most energetic objects in the universe.

"If we thought we had a complete theory of quasars before, now we know we don't," says John Bahcall of the Institute for Advanced Study in Princeton, New Jersey, and leader of one research team. "No coherent, single pattern of quasar behavior emerges. The basic assumption was that

continued on page 30

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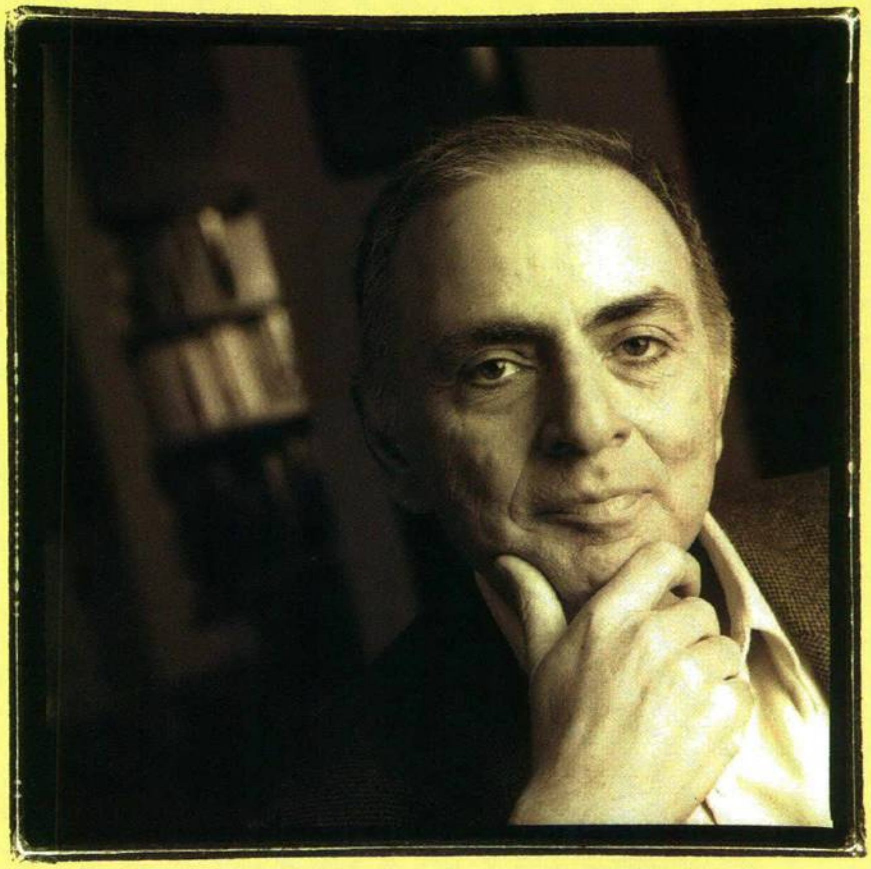
Carl Sagan, 1934–1996


Robert Reichert

The universe lost one of its best friends a few days before Christmas 1996. Carl Edward Sagan died of pneumonia on December 20 at the Fred Hutchinson Cancer Research Center in Seattle, after a two-year battle with bone marrow disease. The death came as a shock to some who treasured his friendship, as only several weeks before he seemed to be improving and, in his words, was "operating at about 80%." The disease that plagued him was myelodysplasia, a form of anemia. Sagan had undergone a bone marrow transplant to counteract the disease at the Hutchinson Center in April 1995.

Sagan will be remembered as a giant in astronomy for his long record of professional accomplishments, his superb writing, and his outstanding ability to communicate complex ideas in simple ways. Despite an extraordinarily busy schedule, he took time to do and say kind and helpful things. A letter of career advice from Sagan helped to spark a small publication called *Deep Sky Monthly* that I launched as a teenager in 1977. He inspired many young astronomers and most of the editors working on the staff of this magazine.

Sagan was brilliant. At a conference on comets and the origins of life, he was likely to rattle off details about the bonds in organic molecules or launch into a discussion of politics and NASA funding. He seemed actually to know it all — and the details of it all. But he could tell you with an inclusive smile that made you feel like an insider.

Sagan was born in New York City on November 9, 1934. At the time of his death he was David Duncan Professor of Astronomy and Space Sciences and director of the Laboratory for Planetary Studies at Cornell University in Ithaca, New York, where he had been since 1968. He played a leading role in the American space program since its inception. Sagan was a consultant and adviser to NASA since the early 1960s, briefed the Apollo astronauts before their flights to the Moon, and was an experimenter on the Mariner, Viking, Voyager, and Galileo missions to the planets. He helped solve the mysteries of the high temperature of Venus (answer: a massive greenhouse effect), the seasonal changes on Mars (windblown dust), and the reddish haze of Titan (complex organic molecules).

For his work, Sagan received numerous awards, including the NASA Medals for Exceptional Scientific Achievement and (twice) for Distinguished Public Service, as well as the NASA Apollo Achievement Award and the Public Welfare Medal, the highest award of the National Academy of Sciences.

He was elected chairman of the Division for Planetary Sciences of the American Astronomical Society, president of the Planetology Section of the American Geophysical Union, and chairman of the Astronomy Section of the American Association for the Advancement of Science. He served as editor-in-chief of *Icarus* for 12 years. He was a co-founder and president of the Planetary Society and a Distinguished Visiting Scientist at NASA's Jet Propulsion Laboratory.

A Pulitzer Prize winner, Sagan was the author of many bestsellers, including *Cosmos*, the top-selling science book ever published in English. The accompanying television series has been seen by 500 million people in 60 countries. He received 22 honorary degrees from American universities. Sagan's last book, *The Demon-Haunted World: Science as a Candle in the Dark*, was published by Random House in March 1996. He was co-producer and co-writer of the Warner Brothers movie *Contact*, based on his novel, scheduled for release in 1997.

The scientific community didn't always embrace Sagan's tireless efforts to popularize science. Yet he accomplished more to interest the public in astronomy, planetary science, and space exploration than anyone else of his time, and for that, all who admire science should be eternally grateful to Carl Sagan.

All of us at ASTRONOMY will feel the loss especially deeply. Sagan had served as an advisor to us on occasion and had agreed to take a leading role on the magazine's new editorial board. The universe shines a little more dimly now. — *Dave Eicher*

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The GP mount has a built-in illuminated polar alignment scope for fast polar alignment.

The premium optics of the **GP-C102** are made in Japan to rigid standards. It has a focal length of 1000mm (f/9.8). The **GP-C102-ED** model features Super ED glass to yield exquisite images of very high contrast and resolution with virtually no chromatic aberration. The ED unit has a focal length of 920mm (f/9) and has multi-coatings.

Standard accessories (the same on both models), include a 20mm Eyepiece – 1¼", 6x30 Finderscope with an 8° field and a Star Diagonal – 1¼". Weight is 39 lbs.

Optical tube assemblies of the 4" refractors are available separately and include tube rings, mounting plate and finderscope.

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Standard accessories include a 20mm H – .96" Eyepiece (35x), 6mm SR – .96" Eyepiece (117x), 2x Barlow Lens – .96", 5x24 Finderscope and a 90° Diagonal.

FIRSTSCOPE 60 DELUXE

The same as the Firstscope 60 except that all the .96" items are replaced with a **hybrid 1¼" diagonal and two 1¼" eyepieces** – 25 SMA (28x) and 10mm SMA (70x).

Celestron offers two 60mm equatorial refractors – the Firstscope 60 EQ and the Firstscope 60 EQ Deluxe.

FIRSTSCOPE 60 EQ

Similar to the Firstscope 60 but the focal length for this telescope is 900mm (f/15).

Standard accessories include a 20mm H – .96" Eyepiece (45x), 12.5mm H – .96" Eyepiece (72x), 2x Barlow Lens – .96", 6x24 Finderscope and a 90° Diagonal. Weight is 11 lbs.

FIRSTSCOPE 60 EQ DELUXE

The same as the Firstscope 60 EQ except that all the .96" items are replaced with a **hybrid 1¼" diagonal and two 1¼" eyepieces** – 25mm SMA (36x) and 10mm SMA (90x).

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The Premium 80 is an ideal first telescope for the more serious beginning astronomer or terrestrial observer.

Its easy-to-use altazimuth mount includes slow-motion controls in both axes with flex cables allowing quick and easy pointing and tracking. The supplied attractive and very sturdy wood tripod is adjustable in height.

Standard accessories include a 26mm multi-coated Plössl – 1¼" Eyepiece (35x) for a wide field of 1.4°, high quality 6x30 Finderscope and a versatile 45° Erect Image Diagonal – 1¼". Weight is 18 lbs.

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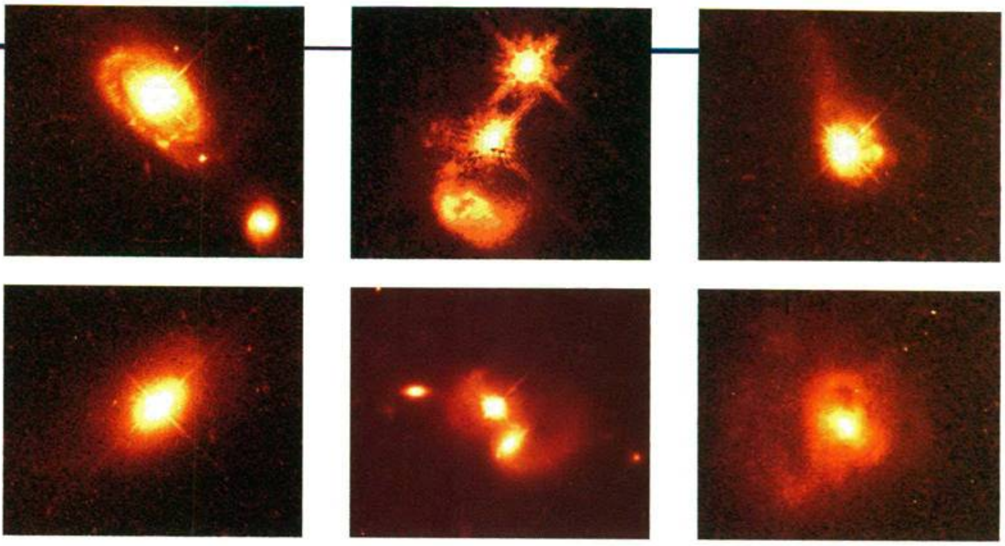


John Bahcall (Institute for Advanced Study), Mike Disney (Univ. of Wales), and NASA

New Hubble images show quasars residing in a variety of galaxies, from normal to highly disturbed. A quasar lies in an apparently normal spiral (top left) and another lies in a normal elliptical (bottom left). Colliding galaxies play host to quasars in the two middle images, while the two images at right show quasars in the cores of peculiar galaxies. The findings suggest that several mechanisms may be able to "turn on" quasars.

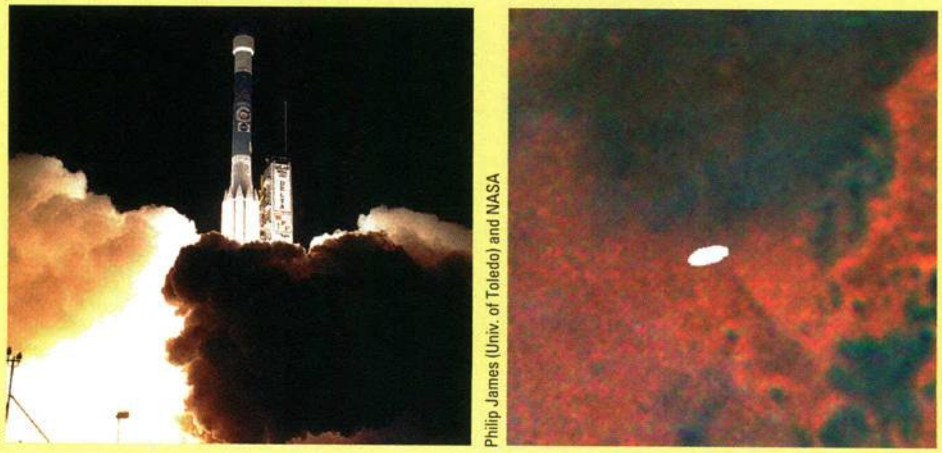
there was only one kind of host galaxy, or catastrophic event, feeding a quasar. In reality, we do not have a simple picture — we have a mess."

A number of the images show quasars in colliding galaxies. "People had suspected that collisions might be an important mechanism for feeding black holes and generating the vast amounts of energy emitted by quasars," says Mike Disney of the University of Wales College in Cardiff, U. K., and leader of the second research team. "Now we know collisions are important and we didn't know that before Hubble."

However, about half of the quasars appear to lurk at the centers of apparently undisturbed galaxies. "Either the interacting companion is very close to the nucleus and below Hubble's resolution," says Bahcall, "or other mechanisms are at work in igniting quasars. Some of the galaxies don't even appear to know they have a quasar in their cores."

The images also show that most quasars lie in the cores of luminous spiral or elliptical galaxies. Previous ground-based observations hinted at underlying galaxies, but it took HST to classify their shapes.

Astronomers expect that new Hubble instruments will help pin down the nature of quasars. Infrared observations with the Near-Infrared Camera and Multi-Object Spectrometer (scheduled for installation during the February 1997 servicing mission) should provide important details on the host galaxies. And the Advanced Camera due to be installed in 1999 will allow astronomers to peer even closer to the nuclei of the host galaxies.



NASA

Philip James (Univ. of Toledo) and NASA

Mars Pathfinder finally got its kick to Mars courtesy of a Delta II rocket booster on December 4, 1996, (left). A rover and its mother ship are on their way to the Ares Vallis region of Mars. Both land on July 4, 1997, with the rover beginning a 30-day crawl across the martian surface shortly thereafter.

Meanwhile, the Hubble Space Telescope continues to observe the region around Pathfinder's landing zone. A white oval 60 by 120 miles marks where the craft will touch down (right). The image, taken on February 25, 1995, shows a resolution of 12 miles per pixel. In the succeeding two years, lower resolution Hubble images (due to the planet's greater distance) have been used to monitor changes.

No More Cosmic Spitballs

Planetary nebulae are the gaseous gravestones of dying stars. Over the last decade, astronomers have taken giant strides in understanding planetary nebulae, but puzzles still abound. The most nagging mysteries deal with the so-called ansae — bright knots of gas shooting away along the long axis of elliptical planetary nebulae. Their location and speed are the most troubling aspects. Ansae lie farther away from the star then the rest of the nebular gas, which means they must have been ejected early. They are also fast, expanding away from the star two or three times faster than anything else in the nebula.

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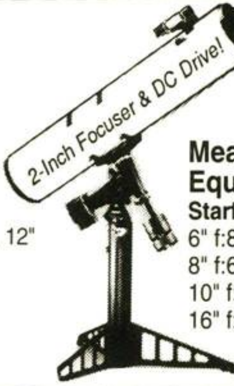

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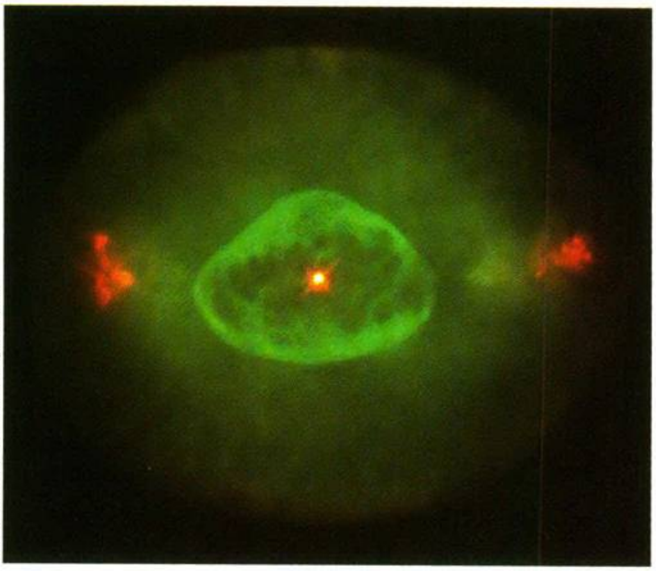


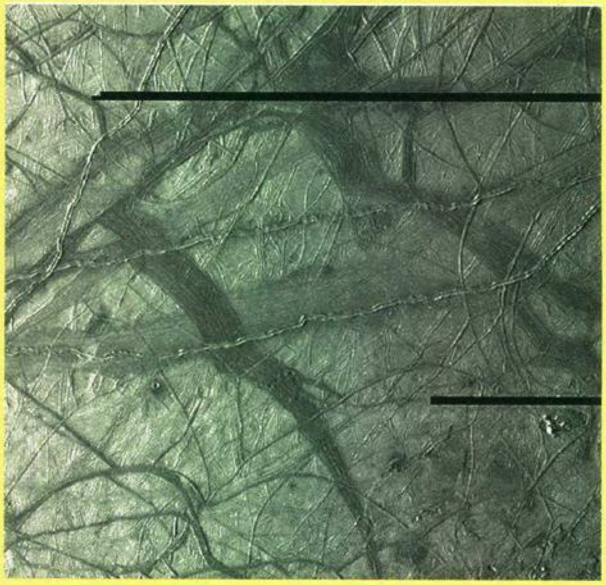
Bruce Balick (Univ. of Washington), et al.

This Hubble Space Telescope image shows bright knots of gas, called ansae, shooting away from the planetary nebula NGC 6826. A new theory explains how the ansae form.

ansae led astronomers to think they were a kind of cosmic spitball — dense blobs of matter shot out by the star just before it expelled the main portion of the nebula. Because no one offered any suggestion as to how this would occur, the idea simply substituted one mystery for another.

A team of researchers has developed a new theory that can account for the ansae. The nebula gets its elliptical shape when a wind from the central star runs into material ejected earlier when the star was a red giant. By observing the wind's interaction during the early planetary nebulae phase, when the gas is very cold, the team found streams of material focused above the poles of the star. When these streams collide, a fast jet of gas gets squeezed out between them. "The process is like holding two garden hoses next to each other and letting the streams of water collide. If you do it at the right angle, you can get a nice tight spray of water — a jet," says team member Adam Frank of the University of Rochester. In the new theory, the era of ansae and jet projection is short lived. The central star heats up as it ages and the heat destroys the focusing effect.

Europa's Fractured Surface



NASA/JPL

The most detailed image yet of Jupiter's icy moon Europa shows a highly disrupted surface with numerous fractures and ridges. Taken by the Galileo spacecraft on November 6, 1996, the image covers an area 238 kilometers wide by 225 km tall that is located 16° south of the moon's equator.

The symmetric ridges visible in the dark bands suggest areas where the moon's crust separated and filled with darker material, somewhat analogous to the spreading centers in Earth's ocean basins. The youngest ridges, such as the two seen crossing the center of the picture, display central fractures, aligned knobs, and irregular dark patches. These and other features could be signs of cryovolcanism, a process related to the eruption of ice and gases.

Although the detail seen in the image is unprecedented, it won't be for long. Galileo took this shot of Europa from a distance of 41,000 km during its close flyby of Callisto. In December, the spacecraft flew less than 1,000 km above Europa's icy surface, returning images with better than ten times this resolution. Keep tuned to ASTRONOMY for all the latest Galileo images and science.

Clustering Seen from Afar?

Since the 1980s, astronomers have known that the local universe is extremely lumpy, dominated by enormous superclusters of galaxies arranged in great walls, all of which surround immense voids. But how far back in time did this hierarchical structure originate? Two studies by Caltech astrophysicist Judith Cohen and colleagues suggest the origin of structure goes back much further in time than many theorists would care to admit.

In the most recent study, Cohen's team used the 10-meter Keck Telescope in Hawaii to take spectra of 140 faint galaxies 3 to 6 billion light-years away. The astronomers were specifically looking for how much the galaxies' spectral lines were shifted toward the red, which gives an indirect measure of distance. To their surprise, they found that the redshifts clustered around six distinct peaks, suggesting they are seeing six distinct walls of galaxies lying at different distances along their line of sight. In the previous study, the team found five peaks in a sample of 106 galaxies.

Because Keck's field of view is only 1/250 the size of a full Moon, it's too soon to know for sure if Cohen's team is seeing large-scale clustering at great dis-

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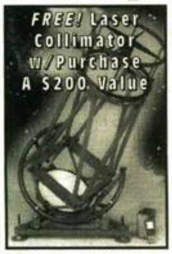

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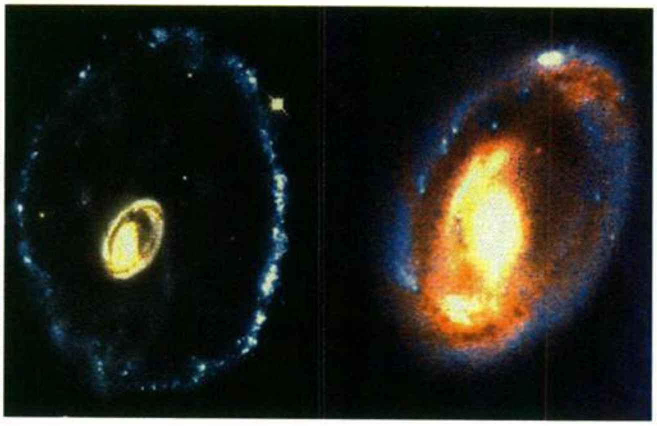

Curt Struck (Iowa State Univ.), et al. and NASA

The Cartwheel Galaxy (left) displays an unusual wagon-wheel shape caused by a nearly head-on collision with a smaller galaxy 200 million years ago. The galaxy's nucleus (right) shows knots of gas shaped like comets, only thousands of light-years long. Most of the knots lie on the core's left side and appear as white streaks inside the blue ring.

tances. Cohen's team is using Keck to observe neighboring fields to see if the walls are continuous. If their initial results are confirmed, it will mean that cosmic structures formed much earlier than theories had predicted.

"Comet-Clouds" in the Cartwheel

Immense knots of gas shaped like comets lie in the heart of the Cartwheel Galaxy, a peculiar looking galaxy that formed when a smaller galaxy collided nearly head-on with it 200 million years ago. New Hubble images may eventually explain why the center of the galaxy shows little star formation and what causes the spokes between the bright outer ring of young stars and the mysterious, dusty nucleus.

Although the gaseous knots may look like comets, they are huge: the "heads" measure a few hundred light-years across and the "tails" stretch more than 1,000 light-years. Vast clouds of molecular hydrogen, similar to those found in our own Galaxy, probably make up the heads, while the tails most likely are incandescent gas.

Curt Struck of Iowa State University and his colleagues report in the November 1996 *Astronomical Journal* that the shape of the structures probably results from a collision between high-speed and slower moving material.

Although the team believes learning the secrets of the Cartwheel must await future observations, they propose a couple of hypotheses to explain the "comets." One holds that the structures arise when massive clouds of gas plow through the inner ring of the Cartwheel at speeds of several hundred thousand miles per hour.

Alternatively, they may form when dense clouds rain down on the inner disk from a bridge of material that connects the Cartwheel to the intruder galaxy. □

EVENT HORIZON

What Dark Matter Is Not

Copious amounts of dark matter surround galaxies like the Milky Way, but it apparently is not in the form of planetary-mass objects. A group of astronomers led by Charles Alcock of Lawrence Livermore National Laboratory has observed stars in the Large Magellanic Cloud for signs of gravitational microlensing caused by intervening objects, the so-called MACHOs. The team reports that they have not found any objects with a mass between that of Mars and Jupiter.

Cassini Should Be Safe

Calculations by Larry Esposito and Robin Canup of the University of Colorado in Boulder show that the Cassini mission should survive its passage through Saturn's rings. Scheduled for launch in November, Cassini will observe Saturn and its rings and moons, as well as land a probe on the surface of the large moon Titan. Previous calculations hinted that the chances of a catastrophic impact with a particle in the rings could be as high as 15% on each orbit. But the new estimate places the figure at less than 1% for the entire mission's 60 orbits.

NASA/JPL

Workers at JPL view the fully assembled Cassini last September.

The Hot and the Cold

Astronomers have known about the white dwarf G261–43 in Cepheus since the early 1900s. But when a team of astronomers led by Ben Zuckerman and Eric Becklin of UCLA recently observed it in infrared light, they found a companion white dwarf just 30 AU from the primary. The primary's temperature is 16,000 K and the secondary's 5,000 K, far and away the largest temperature difference seen in a binary white dwarf.

Weighing a Neutron Star

What is the maximum mass of a neutron star? Because we can't put one on a scale, scientists weigh them on a sheet of paper. Using the latest equations that describe the nature of neutron star matter, Vassiliki Kalogera and Gordon Baym of the University of Illinois calculate an upper limit of 2.9 solar masses, slightly lower than the commonly accepted estimate of 3.2 solar masses. A collapsing stellar core heavier than that will become a black hole. This research will help astronomers tell whether invisible members of binary systems are neutron stars or black holes.

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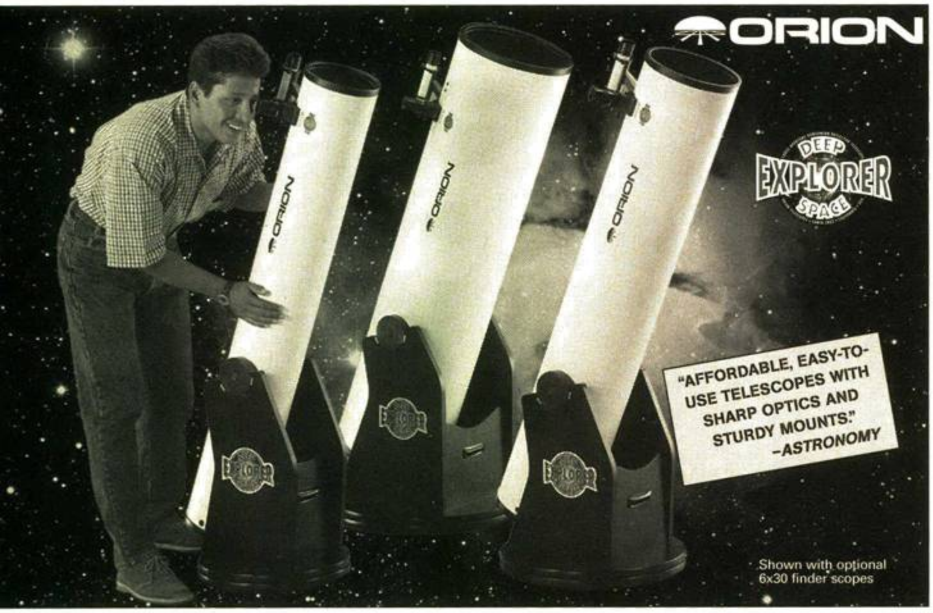
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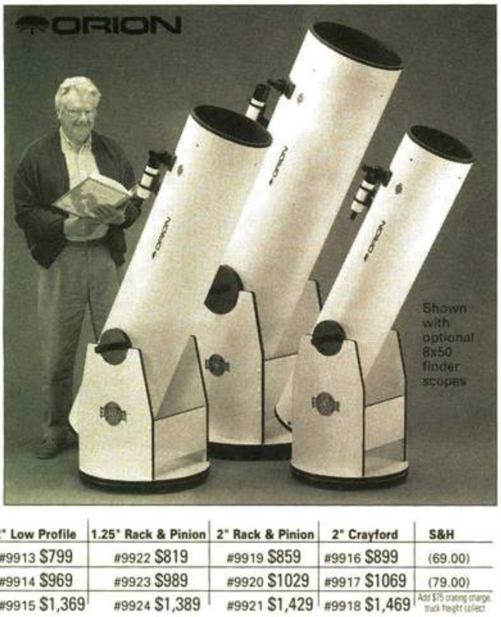
COMES WITH HIGH-QUALITY 26MM PLÖSSL EYEPIECE AND NOW WITH YOUR CHOICE OF FOCUSER!



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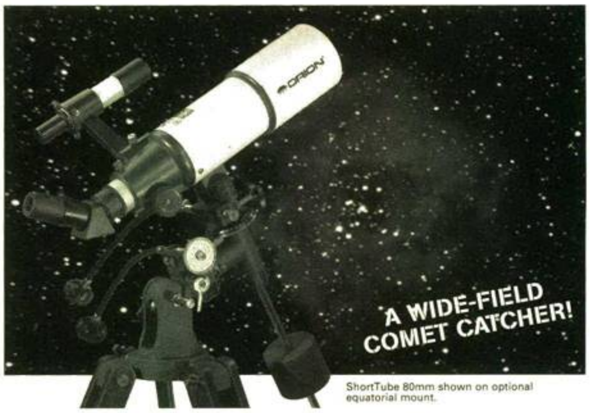

ShortTube 80mm shown on optional equatorial mount.

ShortTube™ 80mm Refractor

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Rich-field 400mm f.l. f/5 scope that's great for observing and prime-focus astrophotography. Features a fully coated achromatic 80mm objective lens, 6x30 finder, 1.25" rack-and-pinion focuser, 45° erect-image diagonal, and TWO 1.25" Kellner eyepieces: 25mm (16x) and 10mm (40x). Attaches to any photo tripod or to Orion equatorial mount (sold separately). Optional carrying bag available.

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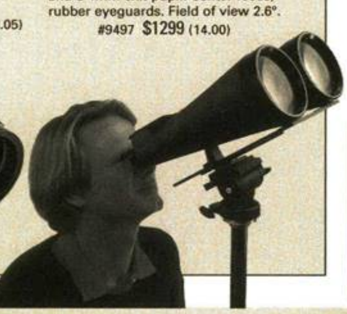

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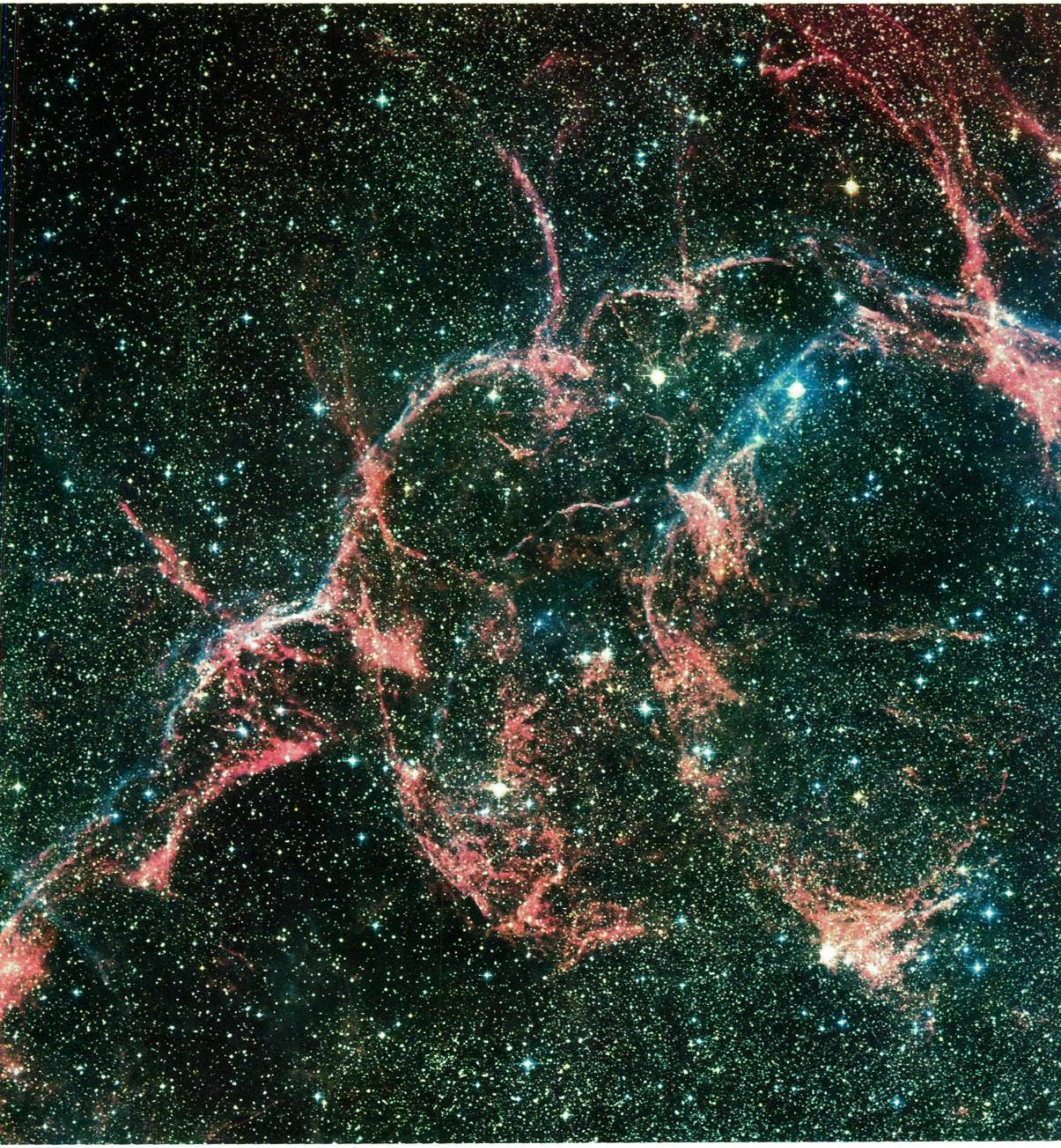
Probing Our Local Cloud



Our local cloud of interstellar gas owes its origin to an explosion near the reddish supergiant Antares.

Anglo-Australian Observatory/Royal Observatory Edinburgh/Photograph by David Malin

by Ken Croswell

British astronomer Fred Hoyle started it. In 1957 he published a science fiction novel called *The Black Cloud* in which a dense clump of gas and dust entered the solar system and caused death and destruction by blocking the Sun's light. Fortunately, this interstellar cloud was intelligent, and it eventually decided to depart from the Earth's vicinity.

Remarkably, in the last 20 years, astronomers have found that Hoyle was at least partially correct: The Sun does indeed reside in a cloud of interstellar gas. It's not a high-density cloud, and it's certainly not an intelligent one, but it has helped astronomers chronicle recent events in our part of the Galaxy — including a violent explosion that erupted on the inner edge of our local spiral arm and splattered debris over hundreds of light-years of space.

"It's incredibly odd that we happen to be within an interstellar cloud," says Barry Welsh of the University of California at Berkeley. "Here's our chance to observe an interstellar cloud in great detail, and it's looking as if it might alter a lot of our preconceived ideas of the interstellar medium."

Between the Stars

The interstellar medium — the space between the stars — is almost completely empty. Even so-called dense interstellar clouds, such as star-breeding grounds like the Orion Nebula, would pass for a perfect vacuum on Earth. Yet terrestrial life owes its existence to this tenuous material, for interstellar matter gave birth to the Sun and Earth 4.6 billion years ago.

The space near the Sun offers insights that apply throughout the Galaxy. "The local interstellar medium is a pretty complex place," says Fred Bruhweiler of Catholic University in Washington, D.C. "You can use this small region as a laboratory for probing the basic physical processes that occur at much greater distances in the interstellar medium."

Even by interstellar standards, most space within a few hundred light-years of the Sun is empty, constituting what astronomers call the local bubble or local cavity. The little gas in the local cavity is roughly a million degrees and emits low-energy X rays, which rockets first detected in the 1960s. Embedded within this cavity lies the local cloud, a wisp of interstellar flotsam that embraces the Sun and other nearby stars.

Despite its proximity, the local cloud is difficult to study, in part because it's so wimpy. "If you viewed the local cloud from afar," says Welsh, "I don't think you'd see a damn thing. It's far too diffuse. Calling it a cloud is perhaps a misnomer; it's more like a piece of

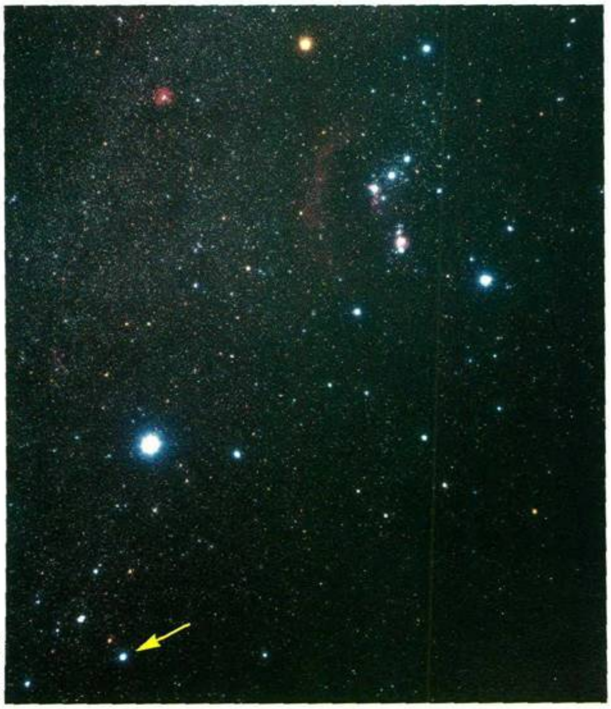
Consisting mostly of interstellar gas swept up by a titanic explosion some 10,000 years ago, the Vela supernova remnant is a younger version of the cloud complex that we inhabit.

cotton fluff." Best guesses put the local cloud's density at 0.2 atom per cubic centimeter, far denser than the local cavity but a far cry from the thousands of atoms per cubic centimeter that make up the densest interstellar clouds and nowhere near the 25 billion billion molecules per cubic centimeter in Earth's atmosphere. The cloud's temperature is only about 8000 K, much cooler than the hot, tenuous region surrounding it.

The local cloud is also difficult to study because astronomers can't look at it from the outside. Astronomers study the local cloud by observing nearby stars. The few atoms in the local cloud between Earth and these stars absorb tiny amounts of starlight, creating absorption features in the stars' spectra. In fact, this is how the local cloud was first discovered, during the late 1970s and early 1980s. Unfortunately, although the local cloud embraces dozens of nearby stars, only the brightest — such as Alpha Centauri and Sirius — provide information. This is because only bright stars radiate enough light for astronomers to detect the local cloud's subtle absorption features.

In some directions, the cloud appears to extend about 30 light-years, but in others, it is just a few light-years across.

Astronomers can probe the local cloud only in those directions that have nearby bright stars. For example, the nearest bright stars in the direction beyond Sirius and Procyon are hundreds of light-years away, and such distant stars reveal little about the local cloud, because any interstellar absorption in their spectra might arise from much more distant material.



Luke Dodd

The blue giant star Adhara (arrowed) in Canis Major lies 13° south of Sirius and is easily visible to the unaided eye. Adhara pumps out prodigious quantities of extreme ultraviolet light that ionizes some of the hydrogen gas in the local cloud.

Because of these obstacles, astronomers have at best a rough picture of the local cloud. In some directions, the cloud appears to extend about 30 light-years, but in others, it is just a few light-years across. During the 1980s, a team of French astronomers led by Rosine Lallement found that the cloud is part of a complex of nearby interstellar clouds that are moving in slightly different directions.

The Sun appears to lie near the edge of the cloud complex. To picture this, imagine viewing the Sun from above the plane of the Galaxy, with the Sun at the center of a giant clock (see diagram, facing page). The center of the Galaxy's disk is located in the direction of 6 o'clock and the nearest section of the disk's edge lies toward 12 o'clock. The Galaxy is revolving clockwise toward 3 o'clock.

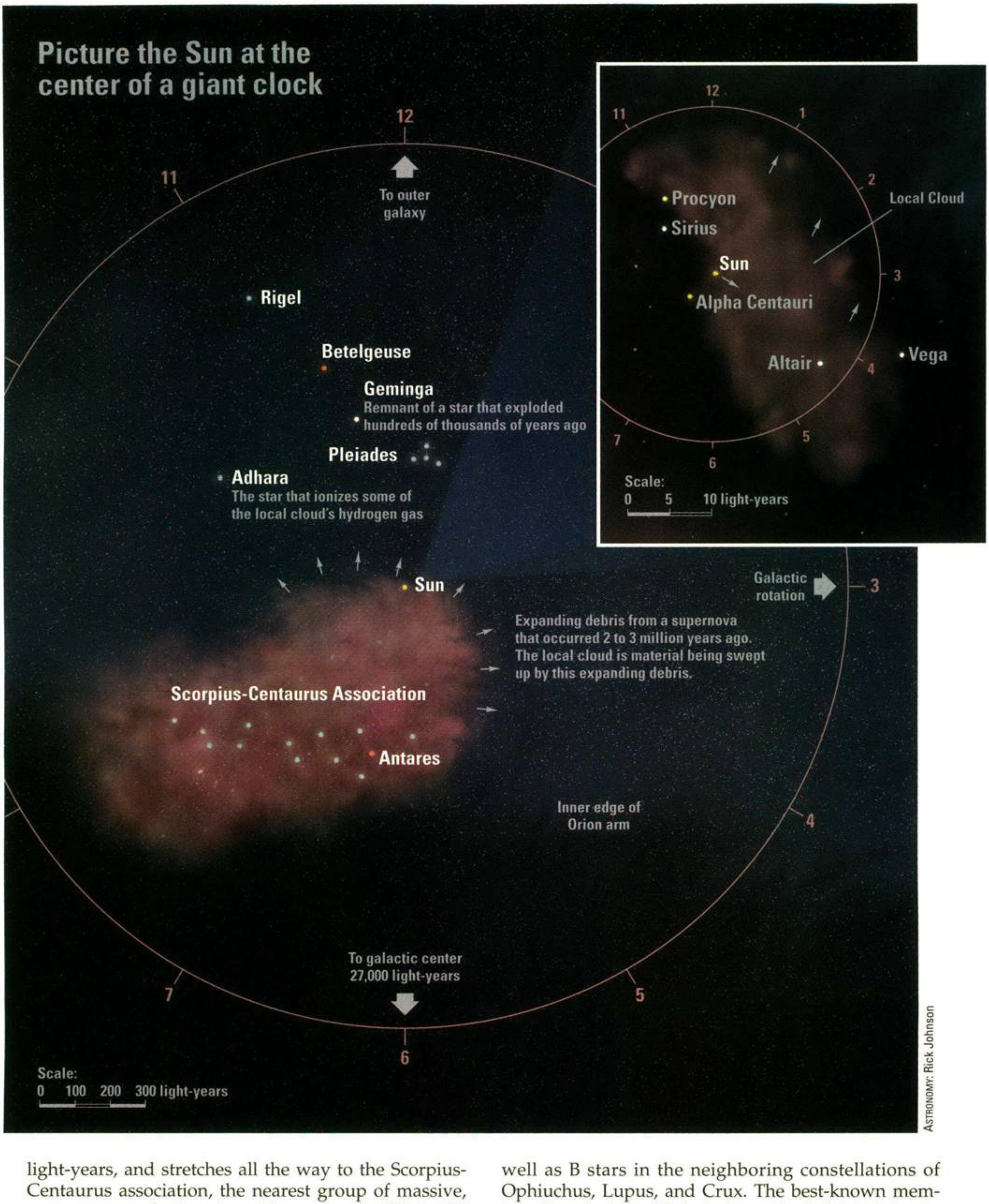
Interstellar material does not seem to extend much beyond Sirius (8.5 light-years away) and Procyon (11.4 light-years away) in the 10 and 11 o'clock directions respectively, because the distant stars beyond them show little more interstellar absorption than Sirius and Procyon do. Instead, the bulk of nearby interstellar material lies roughly toward 4 or 5 o'clock.

But both the cloud complex and the Sun are moving. From the Doppler shifts of the absorption features produced by the local cloud and its neighbors, astronomers have deduced that the local cloud is traveling toward 1 o'clock. The Sun, though, is moving toward 4 o'clock. Because the bulk of the nearby interstellar material lies toward 5 or 6 o'clock, the Sun must be getting closer to regions where the gas is densest.

In June 1996, Priscilla Frisch of the University of Chicago raised the specter that the solar system might face danger some 50,000 years from now, if it encounters a dense patch of interstellar material. At the moment, the Sun shields the Earth from high-energy particles from beyond, because the solar wind forms a protective bubble that encases all the planets. A dense part of the local cloud, though, could compress this shield so that it does not even encase the Earth, exposing the planet to deadly radiation. This claim generated ominous headlines in newspapers. Both Welsh and Bruhweiler, however, dismiss such concerns, because they say there is not yet any evidence for dense concentrations in the local cloud complex.

Explosive Clues

Of greater interest is the local cloud's colorful history — which spans millions of years, hundreds of



Picture the Sun at the center of a giant clock

12
To outer galaxy
11
Rigel
Betelgeuse
Geminga
Remnant of a star that exploded hundreds of thousands of years ago
Pleiades
Adhara
The star that ionizes some of the local cloud's hydrogen gas
Sun
Expanding debris from a supernova that occurred 2 to 3 million years ago. The local cloud is material being swept up by this expanding debris.
Galactic rotation
3
Scorpius-Centaurus Association
Antares
Inner edge of Orion arm
4
To galactic center 27,000 light-years
7
5
6
Scale:
0 100 200 300 light-years
12
11
1
Procyon
Sirius
2
Local Cloud
Sun
3
Alpha Centauri
Altair
Vega
4
7
5
6
Scale:
0 5 10 light-years

ASTRONOMY: Rick Johnson

light-years, and stretches all the way to the Scorpius-Centaurus association, the nearest group of massive, supernova-producing stars. These stars lie 400 to 500 light-years from Earth in the 7 o'clock direction, on the inner edge of the Orion spiral arm. The Orion arm gets its name because it contains the bright stars of the constellation Orion, such as Rigel and Betelgeuse.

The Scorpius-Centaurus association harbors the hot, bright, blue B stars in Scorpius and Centaurus as well as B stars in the neighboring constellations of Ophiuchus, Lupus, and Crux. The best-known member, though, is reddish Antares, the brightest star in Scorpius, which has evolved into an M-type supergiant and will be the next to explode.

"A massive star exploded in the Scorpius-Centaurus association somewhere between 2 million and 3 million years ago," says Bruhweiler. "We're at the outer rim of this expanding complex of gas, so the

Luke Dodd

Two or three million years ago, a star exploded in the Scorpius-Centaurus association that spans from Crux (right), through Centaurus, into Scorpius (off the left edge). The solar system is embedded within a cloud of material swept up by this supernova.

local cloud is really a piece of an old supernova remnant." In fact, the local cloud is moving away from the Scorpius-Centaurus association.

Although supernovae mark the deaths of stars, they eject elements such as oxygen and iron, without which human beings could not exist. However, Bruhweiler says these precious elements constitute only a tiny fraction of the local cloud. The cloud has swept up interstellar atoms during its long journey, just as a snowplow piles up snow. The swept-up material diluted the heavy elements shed by the supernova, so the cloud now consists mostly of hydrogen and helium, the two lightest and most common elements in the Galaxy. Indeed, the cloud's present velocity reflects this snowplow effect: Supernovae shoot out debris at thousands of kilometers per second, but interstellar material has so slowed the local cloud that it now travels at a leisurely 18 kilometers per second.

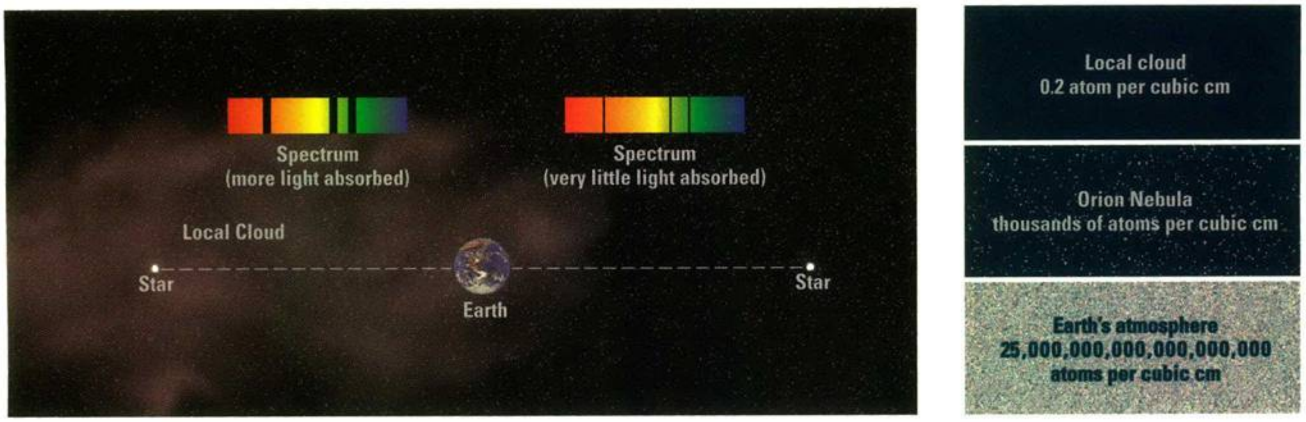
The ionized state of the local cloud's gas is another clue to the cloud's violent history. A neutral hydrogen atom consists of a proton circled by an electron, which takes a lot of energy to remove. But the hydrogen in the local cloud is partially ionized, meaning some of the protons have been stripped of their electrons.

Normally, only extreme ultraviolet light has enough energy to ionize hydrogen. Such radiation, which is emitted by hot blue stars, gets stopped by the Earth's atmosphere. In 1992, NASA launched the Extreme Ultraviolet Explorer (EUVE), a satellite that startled astronomers by locating the one star which, more than any other, is responsible for ionizing the local cloud's hydrogen.

That star turned out to be Adhara, or Epsilon Canis Majoris, a hot B2 giant that lies 600 light-years away. It is toward 10 o'clock, 70 times farther away than Sirius. Welsh had expected that direction to prove a promising hunting ground for EUVE, because a long interstellar tunnel stretches for more than a thousand light-years from there to the Sun. This tunnel is nearly devoid of neutral hydrogen gas, which absorbs extreme ultraviolet radiation with ferocity.

But Adhara was still a big surprise. "EUVE observed Adhara," recalls Welsh, "and the star blew the count rates away. In fact, it nearly caused the satellite to turn the detectors off, because the number of counts was so high. Nobody expected it." Other than the Sun, Adhara turned out to be by far the brightest source of extreme ultraviolet radiation in the entire sky, even though millions of other stars lie closer to Earth. In visible light, Adhara is less of a spectacle. At magnitude 1.5, it is the 22nd brightest star in the night sky. Adhara is not well known because it is greatly outshone by another star in Canis Major, Sirius.

Adhara owes its extreme ultraviolet brilliance to three factors. "It's a unique combination," says Welsh: "Adhara happens to lie down this tunnel of extremely low-density gas; it happens to be a B2 star, so it's hot enough to give extreme ultraviolet flux; and it gives out 10 to 30 times more extreme ultraviolet flux than



ASTRONOMY: Rick Johnson

Because we're embedded within the local cloud, it's difficult to study. Astronomers can learn about its size, shape, and density by observing how it absorbs light from nearby stars — which creates dark lines in their spectra (left). The low density of atoms in the local cloud makes it a near-perfect vacuum (right).

theory predicted. Now if you placed Adhara anywhere else on the sky — not down the tunnel — we wouldn't see it in the extreme ultraviolet."

Adhara's great power extends directly to the local cloud. In 1995, Welsh and his colleague John Vallerga reported that the ionizing radiation from Adhara is seven times stronger than that from all other stars combined. According to Vallerga and Welsh, Adhara alone keeps between 15 and 19 percent of the local cloud's hydrogen ionized.

The true ionization state of the local cloud's hydrogen is presently unknown, however. Bruhweiler says that it may be much higher, around 40 percent, which would mean that something else must also be responsible. That something else, he suspects, was the supernova that shot the cloud our way in the first place. Aside from emitting extreme ultraviolet light, the supernova shocked the gas, which also ionized the hydrogen. Although millions of years have elapsed since the explosion, the cloud is so tenuous that many of its electrons have not yet found protons to rejoin.

After hydrogen, the most common element in the local cloud is helium, which is even harder to ionize. Yet some of the cloud's helium is ionized. This, says Bruhweiler, provides further evidence for the Scorpius-Centaurus supernova, since Adhara and other hot stars can't ionize that much helium.

However, Bruhweiler admits plenty of uncertainty. "Supernovae are the ultimate culprit," he says, "but there's still the possibility that we're chasing the wrong rabbit. Geminga is a pulsar about 500 light-years away in the same direction as Adhara, and some people suggest that it could be very young, maybe much younger than this supernova that occurred in the Scorpius-Centaurus association." Although the supernova that produced the Geminga pulsar hundreds of thousands of years ago did not create the local cloud — the cloud is moving the wrong way for that — the supernova may have helped ionize it.

Other than the Sun, Adhara turned out to be by far the brightest source of extreme ultraviolet radiation in the entire sky.

Support Your Local Cloud

Although astronomers have learned much from the local cloud, its size, shape, and ionization state remain poorly determined. Astronomers do know that the cloud's future is short, because it is much cooler than the gas surrounding it. "It's similar to dropping an ice cube in hot water," says Bruhweiler. "Eventually, the ice cube will be gone. The local cloud is embedded in hot gas, and it's evaporating. If we wait only 10 million years, the local cloud won't be here any more."

That still gives astronomers plenty of time to study the local cloud and the clues it holds about the history of our part of the Galaxy. Someday, perhaps 10 or 20 years from now, the armada of telescopes and satellites now probing the local cloud from near the Earth may receive help from four spacecraft — Pioneers 10 and 11, and Voyagers 1 and 2 — that are heading into interstellar space. Someday they will leave the domain of the solar wind and reach the local cloud. If they survive until then, they will be able to sample the cloud directly and transmit their data back to Earth.

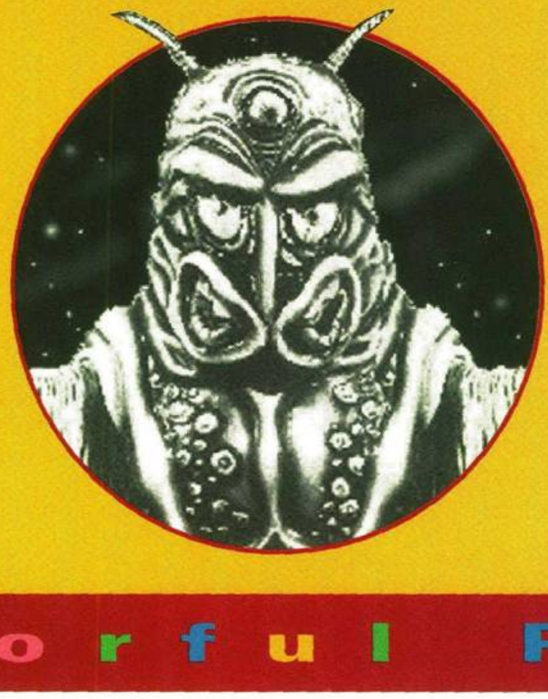
Meanwhile, questions persist about the nature of the local cloud. "Most astronomers think we know everything that's happening in the Galaxy, but I'd argue that we don't even have a satisfactory model of what's happening next door," says Welsh. "We need to focus on our own doorstep just as much as we need to focus on the end of the universe." ☐

Ken Croswell, author of The Alchemy of the Heavens, *is writing a book entitled* Planet Quest. *The home page for both books is: http://www.ccnet.com/~galaxy.*

The Red Planet's Colorful Past

Scientists have been wrong about martian life before. Will they be right this time?

by William Sheehan



Archive Photos/Clip from "The Angry Red Planet"

This is a banner year for Mars. Excitement remains high following NASA's August announcement of possible fossil life-forms in a martian meteorite. Also, two spacecraft are currently en route to the planet: NASA's Mars Global Surveyor and Mars Pathfinder. In July, Mars Pathfinder will attempt to make the first landing on the Red Planet since the two Viking spacecraft in 1976.

And 1997 is an opposition year. On March 17, Earth catches up with Mars in its orbit, as it does every 26 months, so that Mars is favorably placed for observation. Because Mars' orbit is an eccentric ellipse, not all oppositions are equally favorable. At this year's opposition, the planet won't come closer than 99 million kilometers to Earth.

Nevertheless, this is the first opposition in a new series that will see even closer approaches in 1999 and 2001. Finally, in 2003, the planet will swing within 56 million kilometers, bringing it slightly closer to Earth than at any time in recorded history.

Clearly, interest in Mars is greater than it has been in a generation. The prospects of martian life in the remote past, when the planet was able to support liquid water on its surface, are very real. But the history of martian observation warns us that we have been down the road of disappointment before. The idea of life on other worlds is so exciting that it is not always easy to gain a proper perspective, and as Mars comes within range of modest telescopes again, it's worthwhile to recall a few cautionary tales from the past.

Mars is a small world, only half the diameter of Earth, and it never approaches closer than 140 times the distance to the Moon. It therefore shows only a tiny disk in a telescope. Early astronomers were able to make out no more than the gleaming polar caps and smudgy patches on the brighter background. In 1686 the noted French writer Bernard le Bovier de Fontenelle dismissed Mars in only a few words: "It isn't worth the trouble of stopping there."

William Herschel and Johann Schröter made more detailed observations in the late 18th century, but the first astronomers to consider Mars worthy of a map were two Germans, Johann Heinrich Mädler and Wilhelm Beer in 1840. Their map is, of course, crude by later standards, but it shows surface features in an easily recognizable form.

Father Angelo Secchi in 1858 and William Rutter Dawes and J. Norman Lockyer obtained better results during the opposition of 1862. Secchi distinguished subtle tints on the ruddy martian disk. In particular, the dark areas appeared to him as bluish. Lockyer's drawings show just how far observers had come in accurately representing the main features of the planet, which at the time were generally regarded as oceans and continents.

This was before the great martian canal controversy, which began at the memorable opposition of 1877, one of the sub-57-million-kilometer oppositions.

The man who gave Mars the "celebrity" status it has retained ever since was the Italian astronomer Giovanni Schiaparelli. He was already highly respected, and in the 1860s he bestowed his most enduring legacy to astronomy by showing that the August meteors, the Perseids, followed the same orbit as Comet Swift-Tuttle. Those were the heady days when Giuseppe Garibaldi was unifying the Kingdom of Italy. Taking advantage of the political situation by appealing to a newly aroused sense of patriotism, Schiaparelli, by 1875, was able to persuade the king of Italy to give him a new telescope — a fine 8.6-inch refractor, which replaced woefully antiquated instruments. Schiaparelli's chief interest had been to use this new telescope to measure double stars, but with Mars glowing like a red coal in the night sky of autumn 1877, he found the planet irresistible.

At first Schiaparelli did not intend to make a long series of observations, but he soon became enchanted with the delicate forms of the martian disk. He drew up a detailed map and devised a system of nomenclature containing wonderfully evocative names from classical geography and mythology, names that became part and parcel of the romantic lore of the planet ever since — Syrtis Major, Solis Lacus, Elysium, Tharsis. Admittedly, he was not the greatest draftsman who ever lived. His maps are highly schematic, and seemed un-Mars-like to those observers used to more naturalistic representations of the planet. But they made a deep impression at the time.

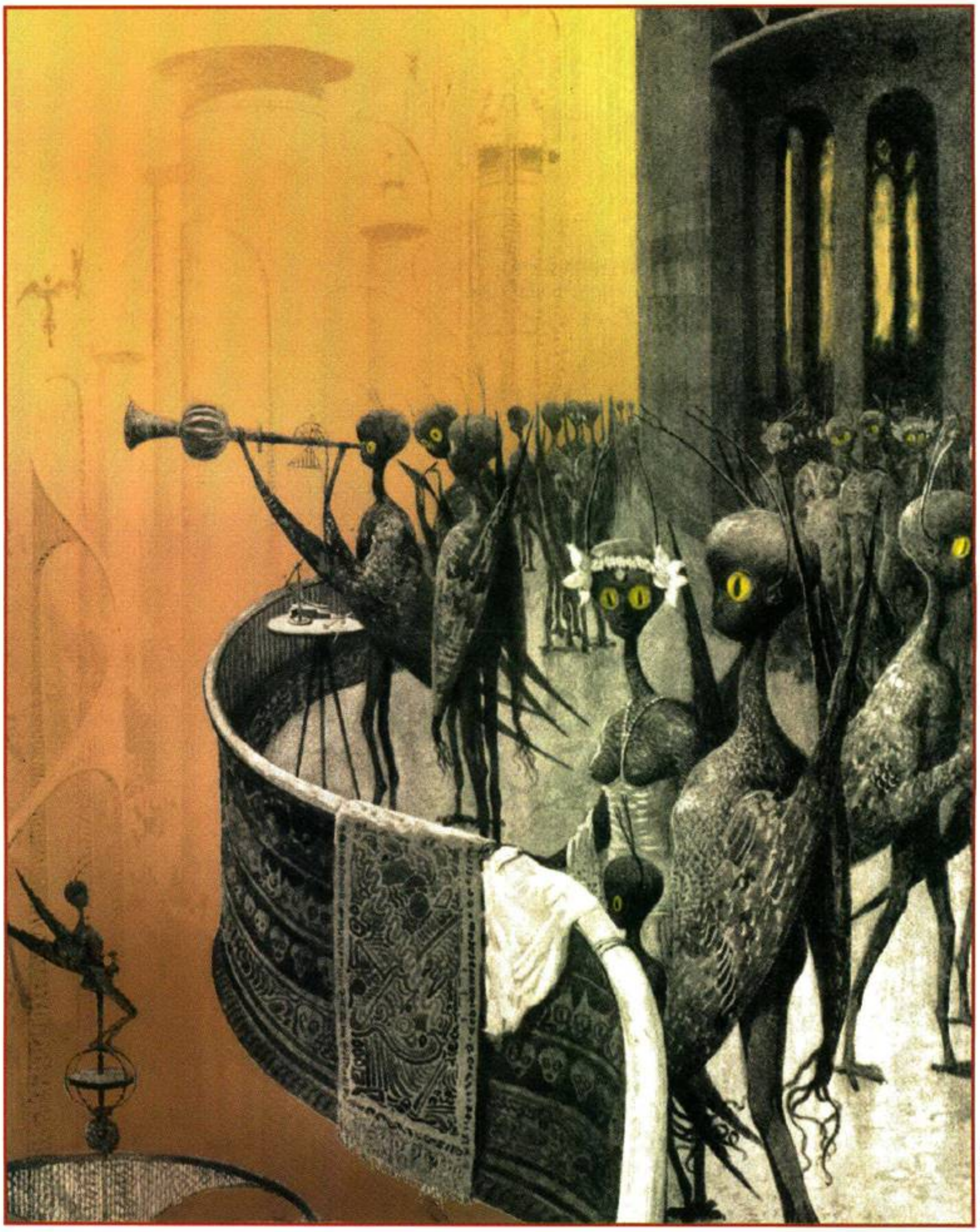
Though Schiaparelli was nearsighted and suffered from red-green color-blindness, he had a keen eye at the telescope. Perhaps too much so, for as his 1878 *Memoir* shows, he became obsessed with minor features on the surface — those near the limit of perception. In moments of super-steady air, he sketched an elusive network of minuscule spots and thin lines. Schiaparelli referred to the spots as "lakes"; the linear features he named *canali*. Because Schiaparelli was a cautious and eminently sober fellow, there is no doubt he innocently meant *canali* to refer to channels, which is what *canali* means in Italian.

Unfortunately, *canali* was immediately mistranslated into English as "canals," with the implication that they had been artificially constructed. This gave a dramatically different coloring to all subsequent observations of the Red Planet.

Indeed, in the 1880s and 90s, the canals became all the rage. Several observatories were built expressly for the purpose of studying Mars — Camille Flammarion's at Juvisy, France, Percival Lowell's at Flagstaff, Arizona, and Vincenzo Cerulli's at Teramo, Italy. With whirring clock-drives and red night lights casting an eerie glow in their dark domes, romantically minded observers rolled their shutters open to the night, peering and sketching the fire-opal disk in the fields of their telescopes as they cast their imaginations across the immense void.

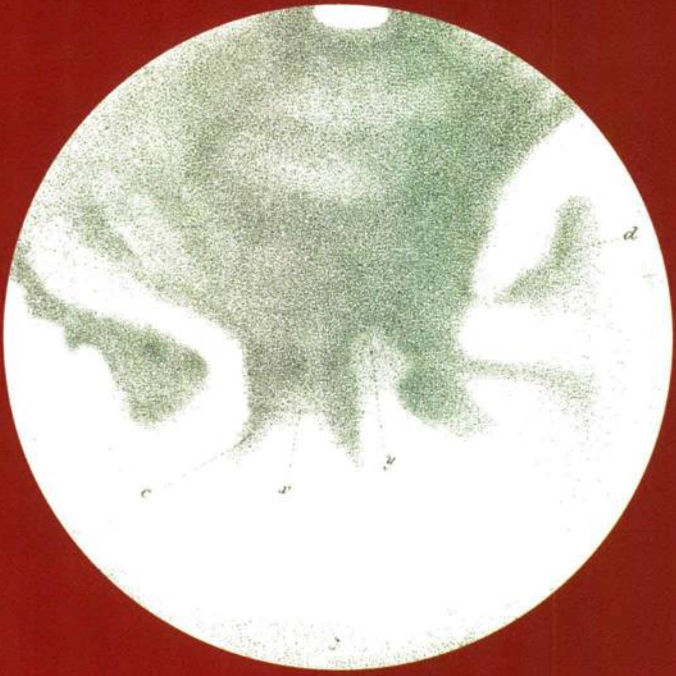
Lowell's concept of the planet, which he developed from 1894 until his death in 1916, took at least part of its inspiration from his mountaintop views of the Painted Desert of Arizona, in which he saw "far forest and still farther desert transmuted by distance into mere washes of color, the one robin's-egg blue, the other roseate ochre . . . None otherwise do the martian colors stand out

When this William R. Leigh illustration appeared in a 1908 issue of *Cosmopolitan*, many people assumed Mars was populated by intelligent beings.

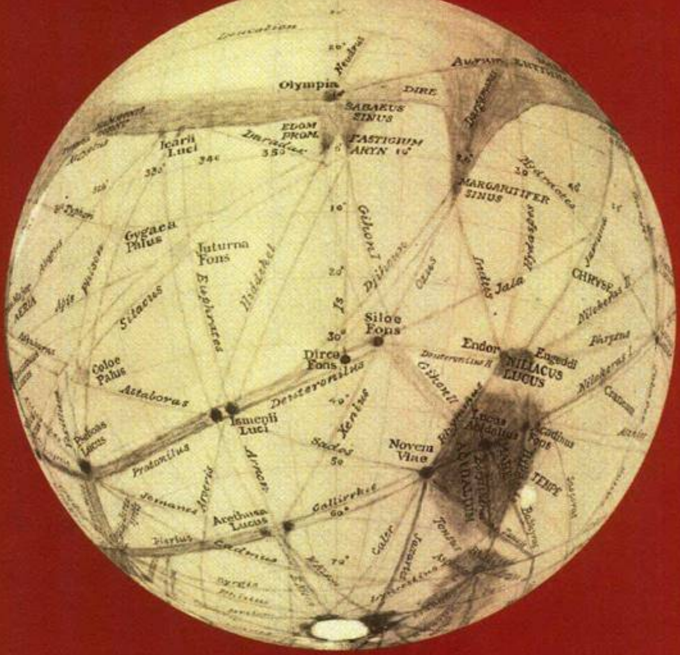


Cosmopolitan

Mars Throug



1862



1903

From left to right:

J. Norman Lockyer drew this map of Mars in 1862. Many astronomers thought the dark areas were tracts of vegetation.
William Sheehan

Percival Lowell's 1903 Mars globe show thin, straight lines — lines that Lowell interpreted as canals excavated by a dying civilization.
Lowell Observatory

When Mars comes closest to Earth, one can easily see dark regions and polar caps through a telescope. These features gave rise to the illusion of a life-bearing planet.
NASA/JPL

The U.S. Geological Survey assembled this Mars mosaic with high resolution photographs from the twin Viking orbiters. The dark areas contain no vegetation, they represent rougher terrain that reflects less sunlight than the surrounding regions.
U.S. Geological Survey

upon the disk at the far end of the journey down the telescope's tube."

Lowell's Mars was a far-off Painted Desert criss-crossed by the canals that he sketched at the telescope — canals built by sapient denizens of the dying planet to transport precious water from the polar caps to irrigate their crops. He also emphasized changes in tint in the dark areas that corresponded to those expected in tracts of vegetation — changes from "greenish-blue to an arid reddish-yellow tint" corresponding with the arrival of water and its subsequent retreat.

Very different were E. E. Barnard's impressions of Mars in 1894, when he viewed it with the Lick Observatory 36-inch refractor. Barnard saw no canals, only hints of a rugged surface "broken by canyon and slope and ridge," similar to the Coast Range that he looked at from his mountaintop observatory in California. It seems that what observers saw on Mars was strongly influenced by terrestrial analogies.

By 1909, the stirring canal fantasies had been all but demolished by the detailed views of the Greco-French observer E. M. Antoniadi, Flammarion's onetime assistant, using Europe's largest refractor — the 33-inch at Meudon Observatory near Paris. Antoniadi argued that Schiaparelli and Lowell had been victims of fragmentary perceptions. Chasing features at the limits of their optical and perceptual means, they had exaggerated the fineness and straightness of features which in reality consisted of "a maze of knotted, irregular, chequered streaks and spots." The canals and the romantic theories that they had inspired were thus shown to be a "grand illusion" by the time the world stood poised on the threshold of World War I.

Not everyone agreed with Antoniadi. For instance, Lowell Observatory astronomer Earl C. Slipher continued to believe in the canals right up until his death in 1964. He produced a quaintly canal-filled map — it was officially adopted by the U.S. Air Force as recently as the early 1960s.

Science fiction writers, of course, preferred Schiaparelli's and Lowell's romance to Barnard's and Antoniadi's reality. Edgar Rice Burroughs, who was thoroughly acquainted with Lowell but had not heard so much of Antoniadi, wrote *The Princess of Mars* in 1912. Burroughs grandly called forth a Lowellian Mars (which he called "Barsoom") of dead sea-bottoms, dry-dust deserts, canals, and hurtling moons. "Theirs is a hard and piti-

h the Ages

Circa 1960s

1970s

less struggle for existence upon a dying planet," Burroughs wrote of his Martians. "The people had found it necessary to follow the receding waters until necessity had forced upon them their ultimate salvation, the so-called Martian canals."

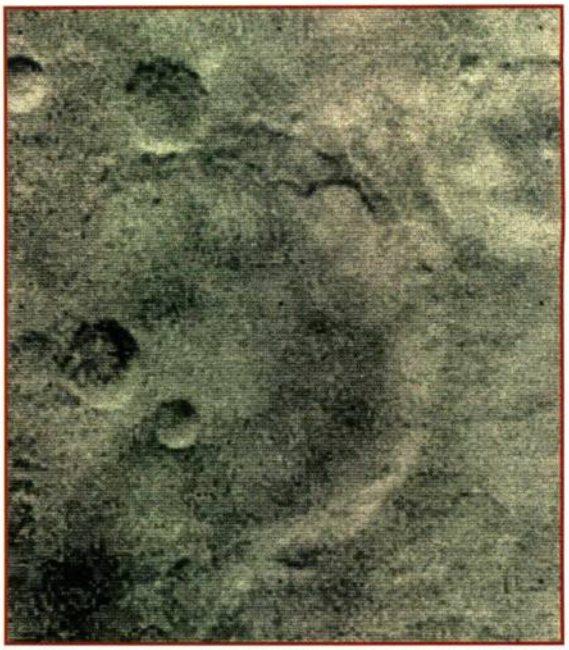
In 1938, the possibility of life on Mars remained so compelling that Orson Welles had no difficulty arousing the fears of a world on the verge of another world war with his Halloween night "Invasion from Mars" broadcast (loosely based on H. G. Wells' 1898 classic *The War of the Worlds*). The canals were still a prominent feature of the martian landscape invoked by Ray Bradbury's *The Martian Chronicles*. Not until 1950 did a science fiction writer depart with fashion by invoking a canalless Mars (Arthur C. Clarke in *The Sands of Mars*).

The canals were not the only illusion affecting martian observations. Another involved the vivid color changes that had given so much credence to the idea that large tracts of vegetation waxed and waned with the seasons. Observers described striking colors. Antoniadi was no exception, and in 1924 he wrote: "Not only the green areas, but also the grayish or blue . . . turned under my eyes to brown, lilac-brown or even carmine." Like Lowell, he believed these transformations were due to sweeping vegetative changes.

In fact the colors were at least in part the result of a perceptual effect known as simultaneous contrast. As dye-workers have long known, the perception of a color is largely determined by the colors surrounding it. In the case of Mars, the dark areas are now known to be drab, dull rusts and gray-browns. But in contrast with the brighter ochre areas, the eye tends to see them tinged with blue-green. ("The blue that is not really blue," as Ray Bradbury once put it.) This illusion played a large role in creating the compelling dream of a living world. Ironically, astronomers might have come closer to a faithful representation of the tantalizing martian disk had they spent more time focusing on what was happening at the small end of their telescopes.

A Mars divested of all illusion seemed to emerge, finally, with the Mariner 4 flyby of 1965. Information had been accumulating for quite some time suggesting that Mars was not the place that astronomers (and science fiction writers) had so long believed in. Pioneer spectroscopists such as Jules Janssen, who set up his equipment on the 9,800-foot summit of Mt. Etna in 1867, had

Mariner 4 offered up a sobering dose of reality. When the spacecraft flew by Mars in 1965, it revealed a bleak, cratered landscape — and no canals.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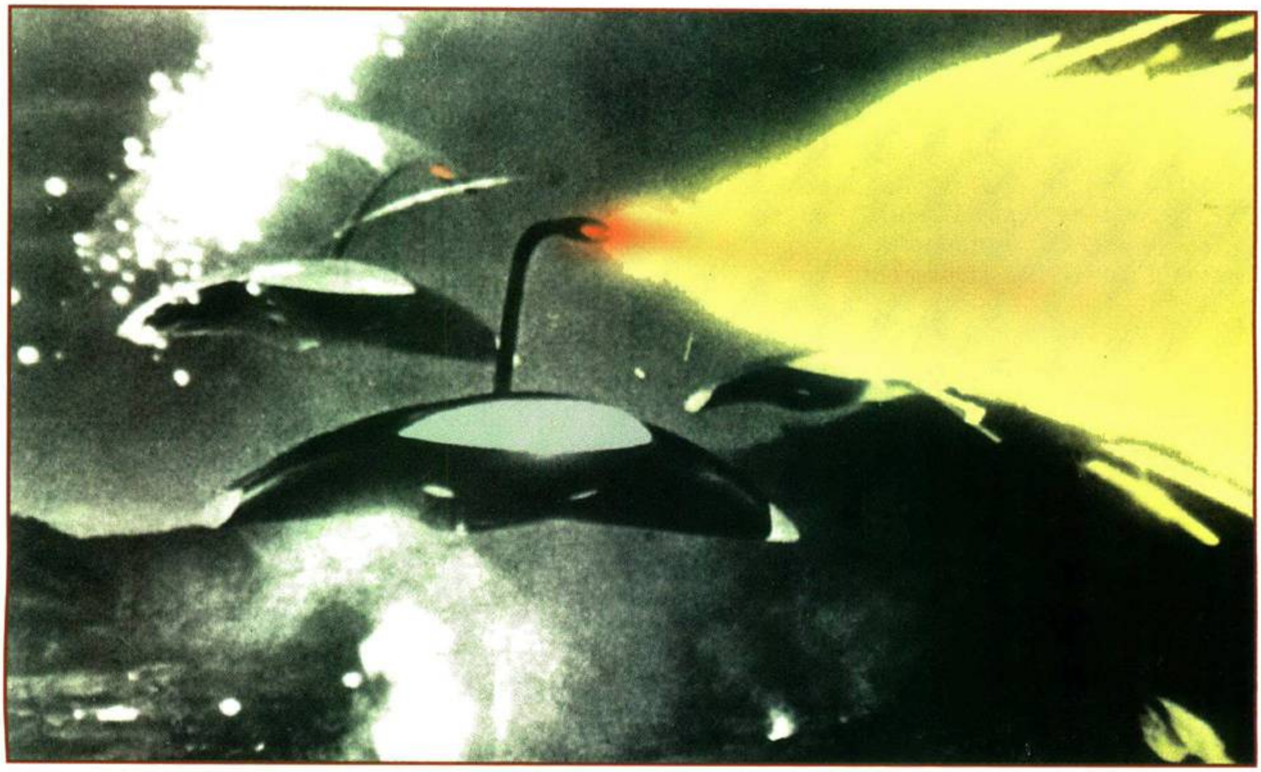
searched for signs of water vapor in the spectrum of Mars. They thought they found it, but this too proved to be an illusion. It was not until 1963 that astronomers using sensitive spectrographs at Mt. Wilson Observatory finally found incontrovertible evidence of water vapor — and then only a trace, a hundred times less than was present over the driest deserts on Earth. The result showed that the martian atmosphere was much thinner than anyone had ever imagined.

Even so, no one was really prepared for the Mariner 4 results. The spacecraft's images showed no canals, though several of them would have shown up — if they existed. Instead the images revealed a bleak and heavily cratered surface like the Moon's. This came as a considerable shock

Archive Photos

Above: Belief in intelligent Martians led to a host of cheesy science fiction movies. This comes from "Mars Attacks the World."

Below: Martian spaceships wreak devastation in this scene from "War of the Worlds," based on the H.G. Wells novel.



Archive Photos

at the time, and the prospects of martian life seemed nil — a dour impression that did not change significantly with the Mariner 6 and 7 flyby missions of 1969.

And yet the drab, moonlike Mars proved no less illusory than earlier enchantments of an Earth-like world had been. Because the dark areas of the southern hemisphere of the planet — the supposed vegetative tracts — had always attracted the most interest, the Mariner flybys had been purposely directed over them. It turns out, however, that these areas contain some of the oldest, most heavily cratered terrain on the planet. By sheer chance, the cameras of these spacecraft had missed the most dramatic features of the martian landscape — the volcanoes, canyons, and dry riverbeds, which were finally revealed by the Mariner 9 orbiter in 1971.

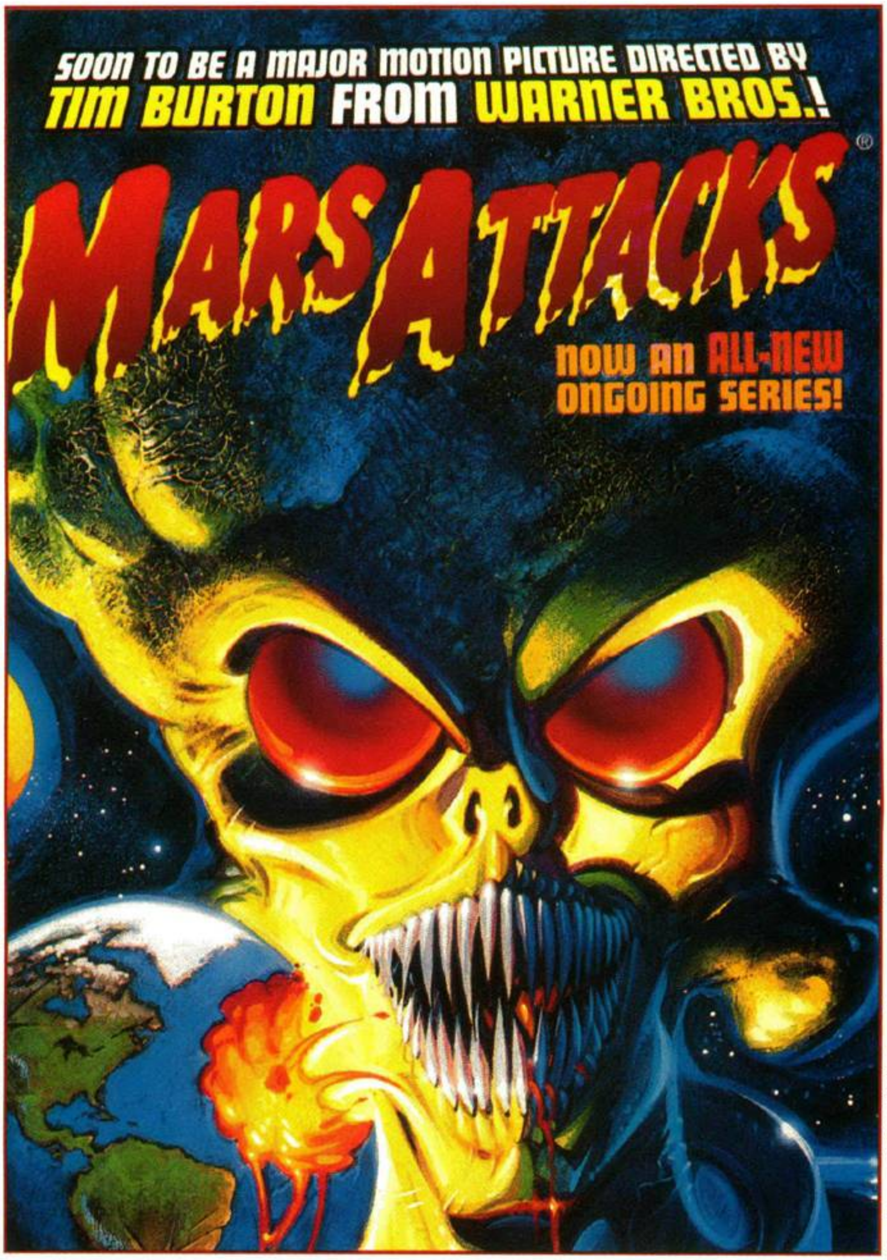
Mariner 9's most startling finding was that liquid water had flowed on the martian surface in the remote past, billions of years ago. Mars has not always been as dry or inhospitable as it is now, so it is at least possible that life might have gotten a foothold early in the planet's history.

Following up on the Mariner 9 results, the Viking landers of 1976 searched for life. When the so-called labeled release experiment showed an immediate and startling peak of carbon-14 radioactivity, the experiment team sent out for bottles of champagne. The "chicken soup" experiment also produced dramatic but rather perplexing results: a sudden burst of oxygen when a nutrient-enriched sample was humidified, which was something that had never occurred in earlier tests with terrestrial samples. However, the mass spectrograph failed to identify any organic compounds — the raw ingredients for life — and the other results were soon accounted for by exotic inorganic chemistry. Most scientists conceded that Viking did not furnish evidence of life. As had happened so often in the quest for martian life, the champagne bottles had been uncorked prematurely.

This brings us to last August's startling announcement from NASA: the evidence of fossilized life found in a martian meteorite. The public reaction was no less robust than the reaction to the "chicken soup" experiment carried out by the Viking landers had been. Clearly, the fascinating world of Schiaparelli and Lowell has remained in the human imagination, waiting for just such an announcement to crystallize its hopes. Humanity's ageless aspiration to find an echo of itself in the universe has once again hauled in the usual suspect — Mars.

The cautionary tales gleaned from past martian studies have underscored our tendency to see analogies to Earth where none exist. In the past, the supposed analogies have always proved illusory. Will this again prove to be the case? Will Mars prove to be the abode of life after all — of past life at any rate? With a new wave of spacecraft setting out for the planet and martian meteorite samples waiting to be tested in laboratories on Earth, 1997 may be the year we finally find out. ☐

William Sheehan is the author of The Planet Mars: A History of Observation & Discovery *(University of Arizona Press, 1996). He co-wrote "Neptune's Discovery 150 Years Later" in the September 1996 issue.*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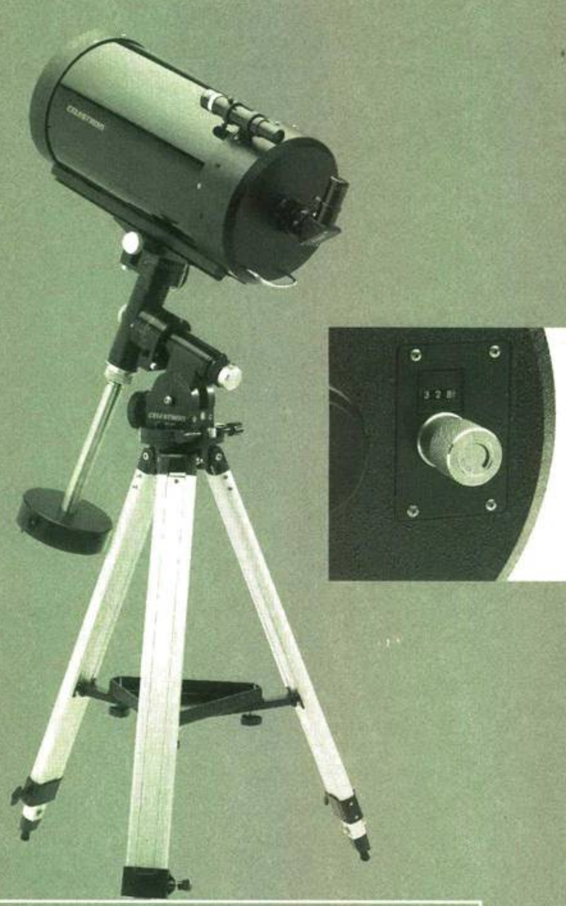

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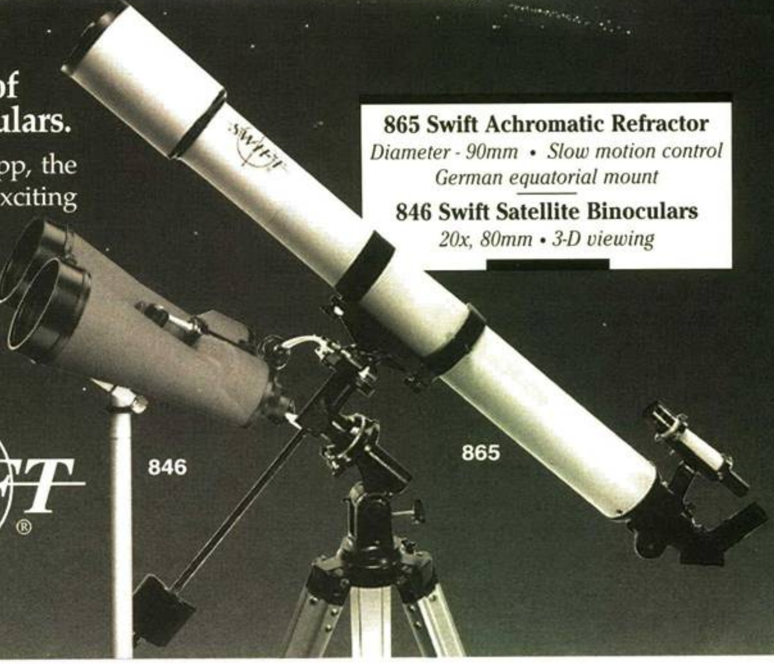

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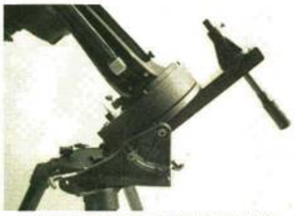
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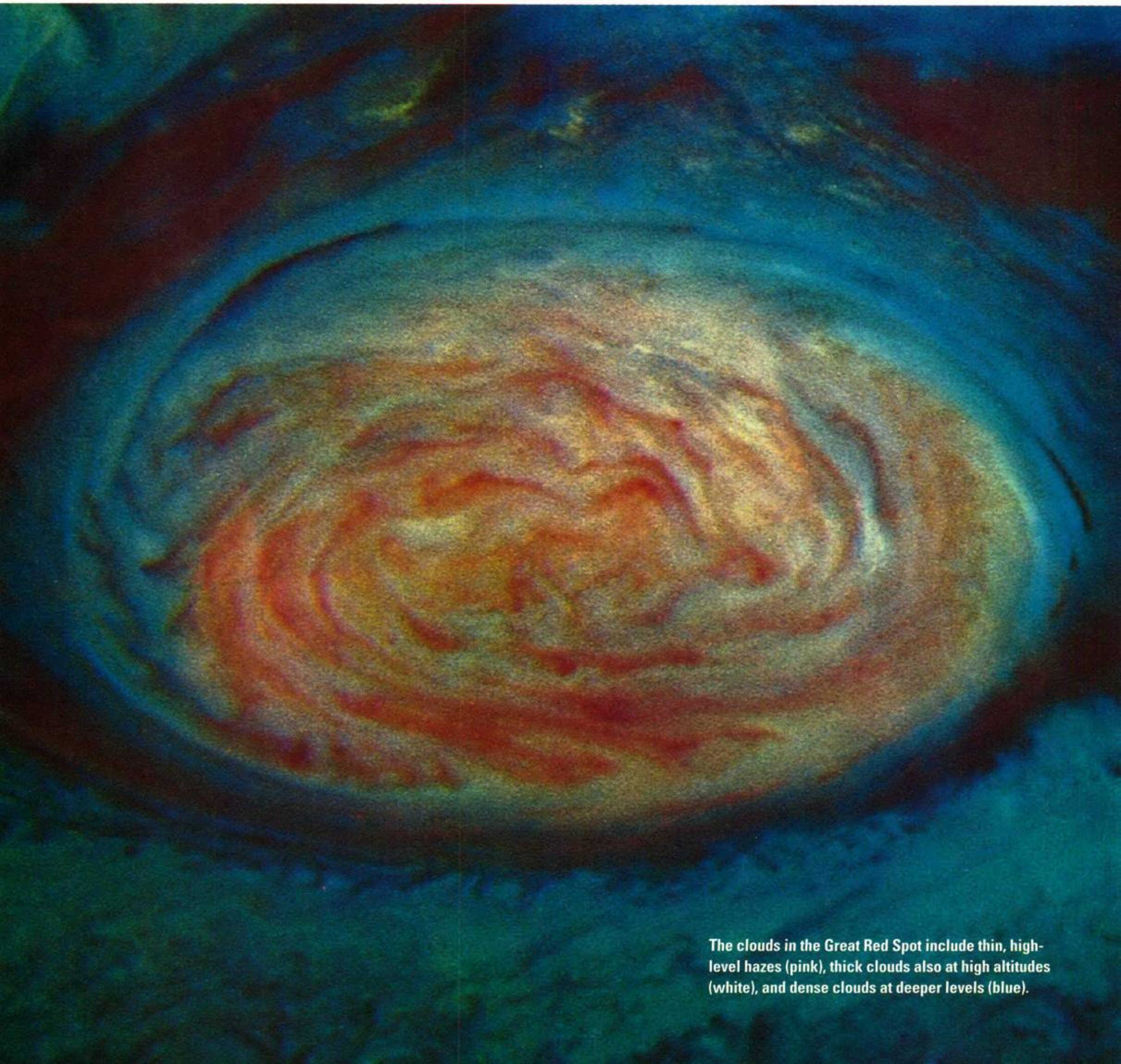
WRITE NO. 31 ON THE READER SERVICE CARD

Galileo Opens New Vistas

Jupiter and its intriguing satellites begin to yield their secrets to the probing eye of the Galileo orbiter.

by Richard Talcott



The clouds in the Great Red Spot include thin, high-level hazes (pink), thick clouds also at high altitudes (white), and dense clouds at deeper levels (blue).

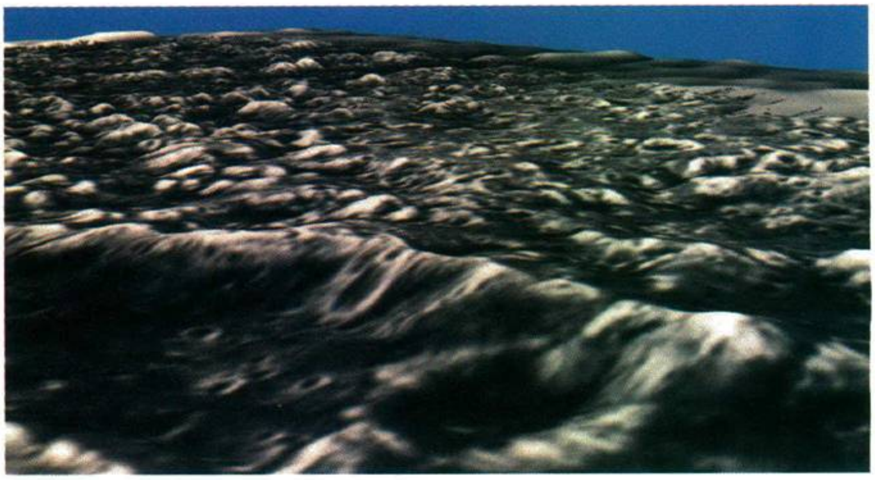
From the cloudtops of Jupiter to the volcanos of Io, and from the ice plains of Europa to the grooved terrain of Ganymede, the jovian system displays a rich diversity of geologic landforms and atmospheric dynamics. Of course, planetary scientists knew much of this before Galileo arrived at Jupiter in December 1995. But the detailed images and other data beamed back from the spacecraft's first two orbits of the giant planet brought smiles to scientists and a host of unexpected results.

Despite a faulty high-gain antenna and a balky tape recorder, Galileo has delivered the goods. Perhaps most heartening to astronomers faced with a somewhat diminished scientific return has been the spacecraft's capacity to generate new results. As project scientist Torrence Johnson of JPL puts it, Galileo "has met and even exceeded our expectations in its ability to surprise."

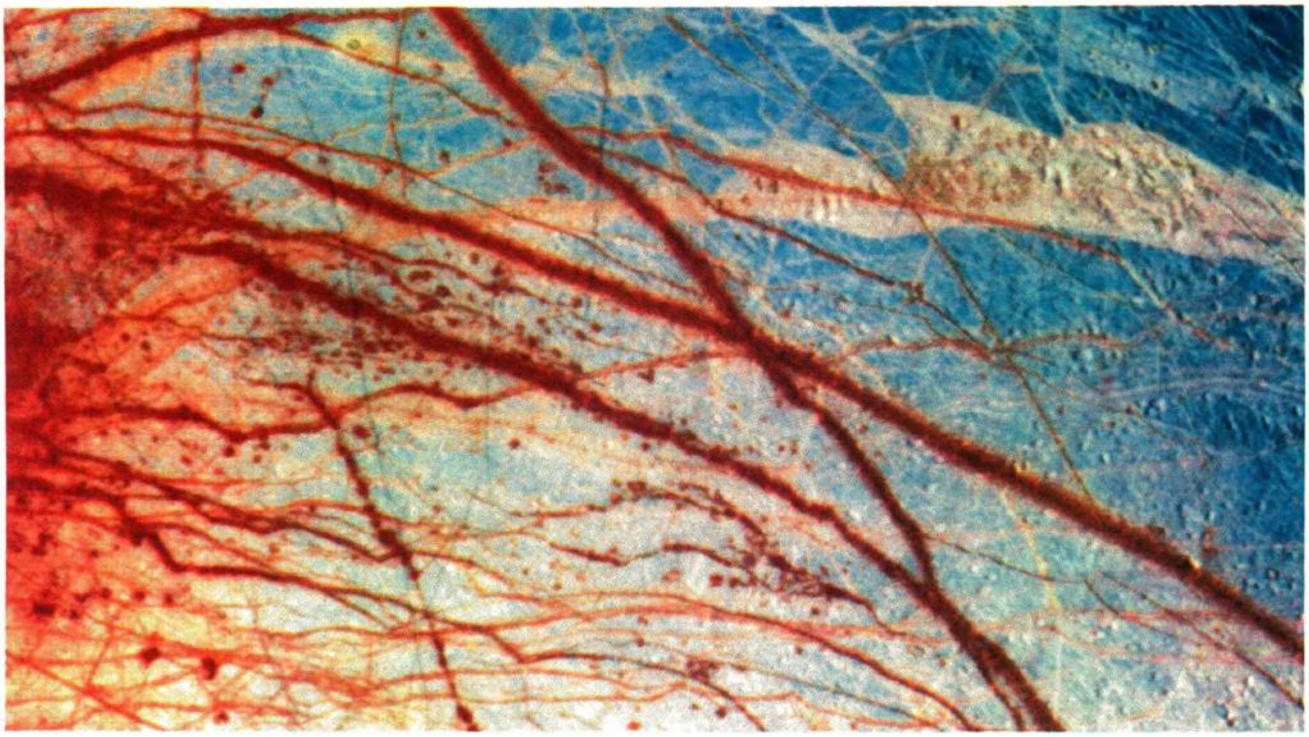
The startling discoveries began with the suicidal plunge of Galileo's atmospheric probe into Jupiter. Among other things, it found nowhere near as much water as predicted before Galileo's arrival. That discrepancy may stem from its entry into a so-called infrared hot spot, a relatively cloud-free zone that allows a view into deeper, warmer layers. Preliminary results from the orbiter's Near-Infrared Mapping Spectrometer have confirmed the low water abundance in the hot spots but also found evidence for water elsewhere in the jovian atmosphere, perhaps alleviating a potentially serious problem for theorists modeling the planet.

Much of the orbiter's initial scrutiny of Jupiter focused on the Great Red Spot, a high-pressure system larger than Earth that has been observed for perhaps 300 years. Galileo imaged the Red Spot at near-infrared wavelengths to reveal the heights of its clouds. In

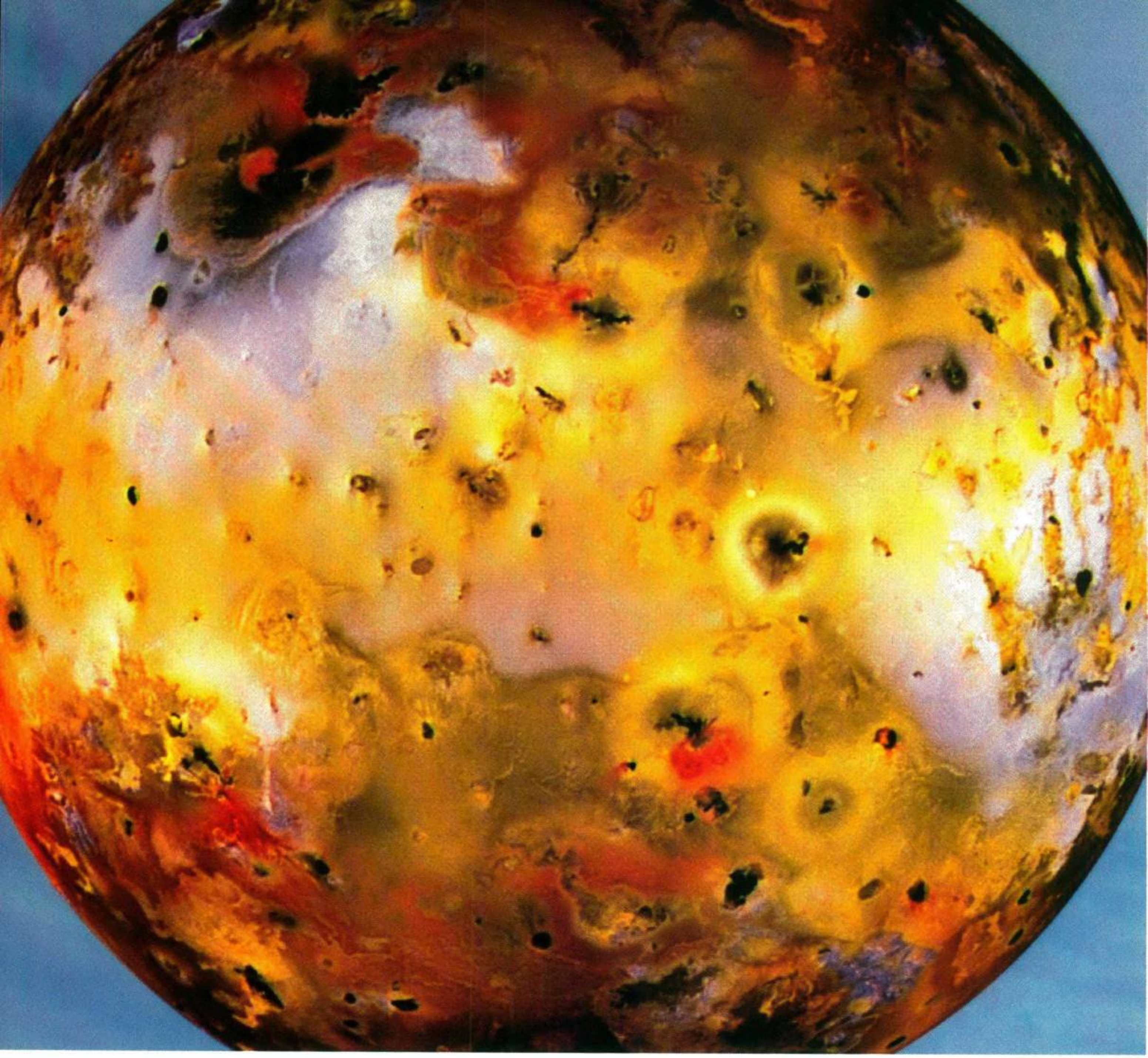
Deep furrows and impact craters stand out in this stereoscopic view of the Galileo Regio region of Ganymede. Using images taken during the first two flybys, planetary scientists created this view to bring out topographic detail. The blue color of the sky is artificial.



A rich tapestry of features spreads across the Minos Linea region of Europa (below). The red and brown areas mark the presence of contaminants in the ice. The icy plains, shown in shades of blue, are broken into units that reflect different amounts of heat from the Sun.



All images: NASA/JPL



Floating above Jupiter's cloudtops, volcanic Io displays a wealth of detail. Black and bright red areas mark the most recent eruptions, some probably just a few years old.

the false-color image that opens this article, pink represents high, thin hazes, white denotes high, thick clouds, and blue reveals deep clouds visible through holes in the upper layers. The dark brown color surrounding the Red Spot depicts a thin haze lying above a region of low clouds.

The scientific bonanza from Galileo consists of much more than images, however. In fact, when the spacecraft flew 900 kilometers above Io just before swinging past Jupiter in December 1995, it took no images. But the spacecraft's other instruments remained focused on the volcanically active inner moon of Jupiter, and their data have now been analyzed.

The plasma science experiment provided the biggest surprise, recording the orbiter's passage through Io's ionosphere. "Sensors recorded a very dense region of ionized oxygen, sulfur, and sulfur dioxide pumped there by Io's relentless volcanic activity," says Louis Frank of the University of Iowa, principal investigator on the plasma experiment.

Galileo scientists were taken aback because Voyager images showed Io's volcanic plumes reached at most a few hundred km above the surface and observations made by Pioneer 10 implied the ionosphere extended only about 100 km above the surface. "No one expected to see this at an altitude of 900 km," says Frank. The change between what Pioneer 10 saw in 1973 and what Galileo saw in 1995 suggests that Io's atmosphere and ionosphere vary in size, growing and shrinking with the level of volcanic activity.

The finding may support a theory proposed by Torrence Johnson that invisible "stealth plumes" deliver volcanic gases to great heights. Io's weak gravity apparently lets the volcanos loft invisible gases to altitudes far above the dust-laden plumes that reflect sunlight and show up in images.

Since the initial flyby of Io, Galileo has studied the moon on each orbit. Planetary scientists are still documenting all the surface changes seen since the Voyager flybys 17 years ago. The most dramatic include new flows and other deposits surrounding the shield volcano Ra Patera, which were first detected by HST in 1995, and the volcanic plume Marduk.

Changes at Loki and Kanehikili — volcanos associated with persistent, high-temperature hot spots — have been much more subtle. The contrast may stem from different types of volcanism. The flows around Ra Patera and Marduk, which do not show intense hot spots, appear dominated by sulfur, while Loki and Kanehikili could be examples of much hotter silicate volcanism. Whatever the reason, the changes hint at the diversity of Io's eruptions.

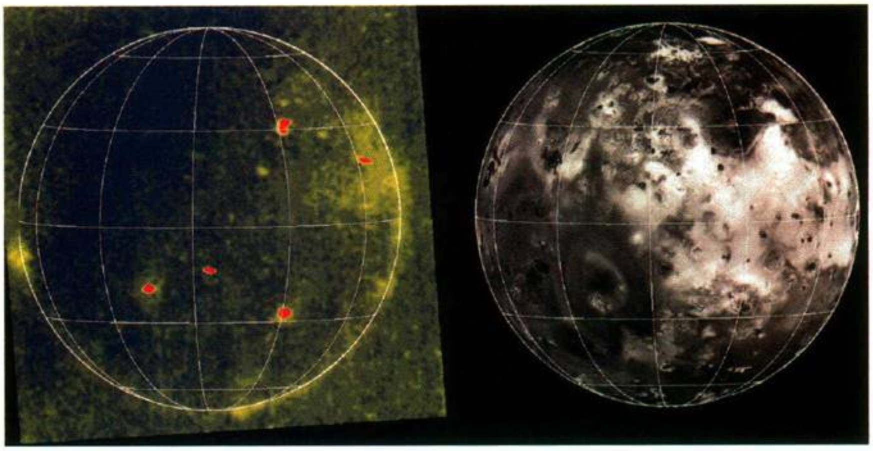
The volcanos owe their existence to tidal stresses from massive Jupiter acting in concert with the gravitational pull of the other jovian satellites. Tidal stresses also affect Europa, the next moon out from Io, but to a far lesser extent. One sign of this heating could be the moon's relatively young surface, which shows few impact craters (though a small number stand out in the global image shown on page 5).

Surprisingly, Europa's bright, icy plains divide into two units. Although nearly indistinguishable at visible wavelengths, the two regions reflect different amounts of light in the near-infrared. The brighter near-infrared regions, shown as a lighter blue in the false-color image on page 53, may consist of smaller ice grains.

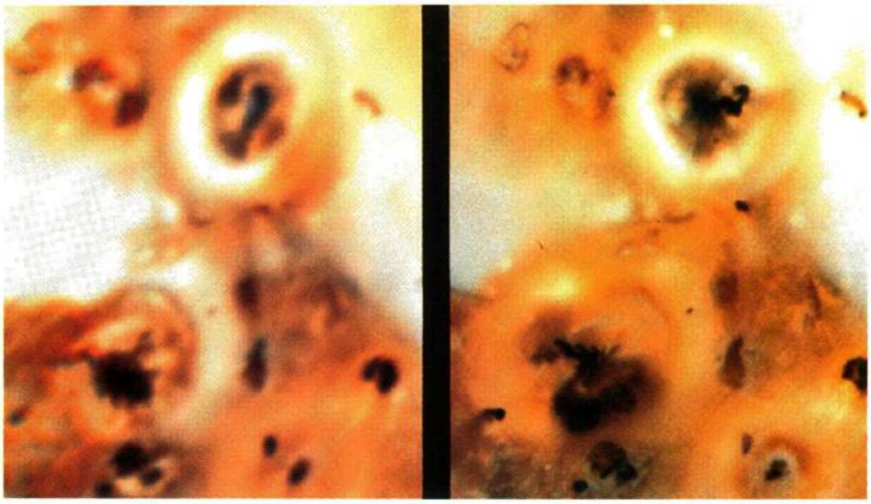
The most detailed images returned so far by Galileo are of Ganymede, the largest moon in the solar system and the target of the mission's first two flybys. Those images, many of which appeared in ASTRONOMY's October, November, and February issues, show details in the moon's unique grooved terrain, a jumble of overlapping regions of different ages, and abundant water-ice frost at far northern latitudes.

Perhaps the most stunning news about Ganymede came from Galileo's magnetometer, which discovered an intrinsic magnetic field. Coupled with new gravity measurements that show Ganymede has a massive core, scientists now lean toward a model of the moon's interior consisting of three zones: an iron-sulfur inner core, a rocky outer core, and an icy mantle. The inner core presumably exists in a liquid metallic state, and convection in that zone creates the magnetic field.

Although Galileo has enjoyed remarkable success, it's just getting warmed up. After the two Ganymede flybys, the spacecraft flew past Callisto in November and Europa in December. Data from those encounters were still being radioed to Earth as we went to press; expect to see those results in the near future. And then wait for the bounty to follow from the six flybys scheduled in 1997! □



Even when eclipsed by Jupiter, Io's surface glows brightly (left). The small red ovals are volcanic hot spots with temperatures of more than 600 kelvins. The diffuse greenish areas near the limb are probably aurorae or airglow emissions arising in volcanic plumes. A 1979 Voyager image (right) shows the volcanic features corresponding to the hot spots.



Similar in size, shape, and brightness when viewed by Voyager in 1979 (left) and Galileo in 1996 (right), Io's volcano Prometheus (at upper right) nevertheless sported a dark new lava flow and a plume erupting 75 km west of where the volcanic hot spot resided in 1979.

Observing opportunities abound as Hale-Bopp streaks

Close Encounters of the Comet Kind

by Alan Hale

The month of March always seems to produce the best comet displays. At least that's been true for the 27 years that I have been watching these visitors from afar. First, there was Comet Bennett in 1970, which I remember as a long-tailed ornament glistening in the pre-dawn March skies. Six years later came the glorious Comet West, a spectacular object that lit up the morning skies of March 1976. Halley's Comet came by in 1986 and, while not quite living up to the standard set by the previous two comets, it was nevertheless an easy naked-eye visitor in the March morning skies of that year. Finally, we were treated to a brilliant display by Comet Hyakutake as it streaked by just over 0.1 AU (14 million km) from our planet on March 25th.

It appears that March 1997 will provide us with yet another brilliant comet — Hale-Bopp (1995 O1), discovered in July 1995, and perhaps one of the brightest comets we've ever seen. It has a special meaning for me because I co-discovered it on a Sunday morning about a year and a half ago.

Hale-Bopp's closest approach to Earth occurs on March 22, and it will reach perihelion, its closest approach to the Sun, on April 1. The spring skies should provide a fine backdrop for this object as it makes its pass through the inner solar system. It's difficult to say at press time just how bright the comet will be, but if it lives up to its potential, Hale-Bopp could be one of the brightest comets of the century.

As I write this, the comet's brightness is holding close to its predicted value. I am cautiously optimistic, but this comet could be one or more magnitudes fainter or, brighter than the predictions. Estimates about the length of its tail during March also can be little more than guesswork. In October, experienced observers were reporting a tail up to 2° long or longer, suggesting that it could be quite spectacular by March.

Hale-Bopp in March: A Summary

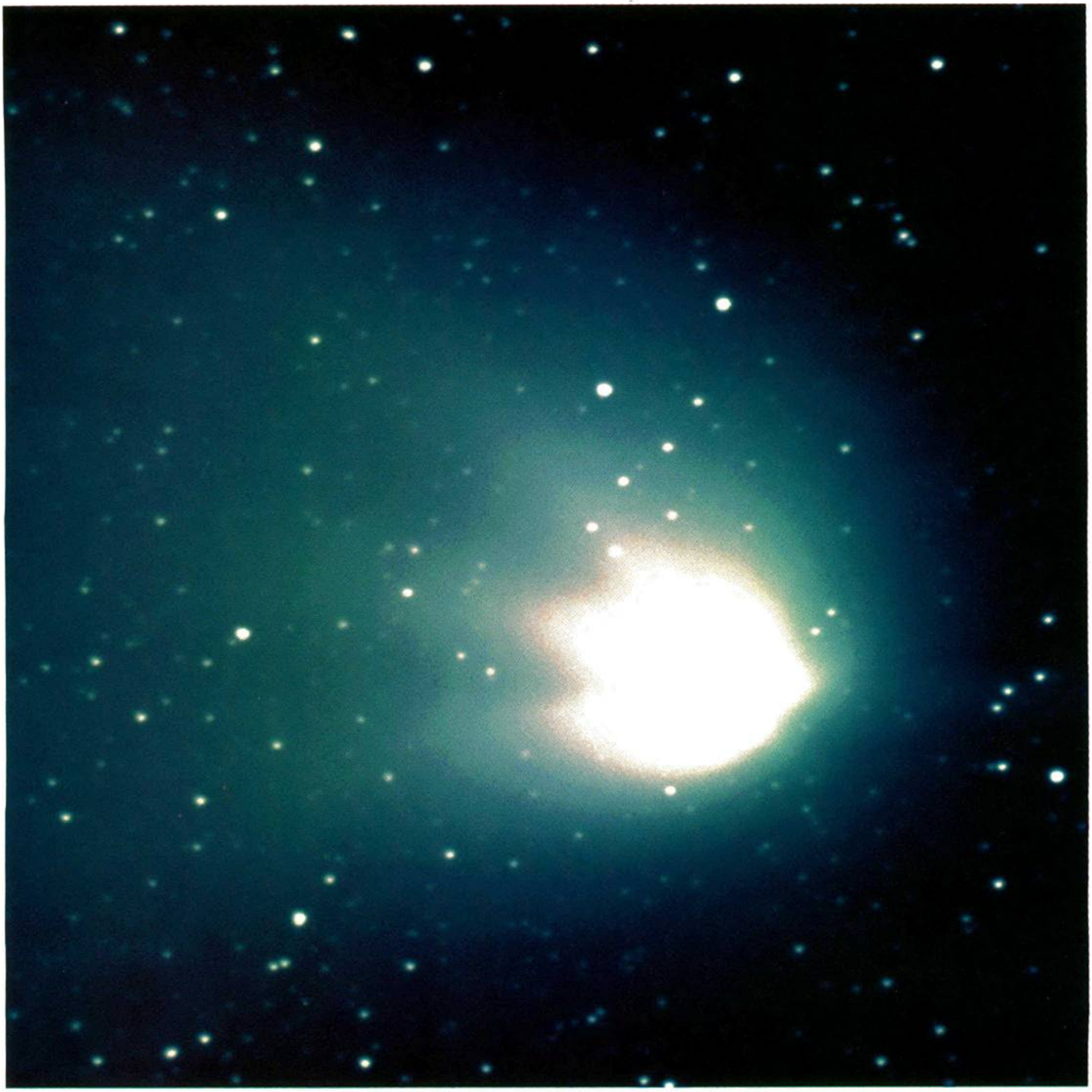
As March opens, Comet Hale-Bopp will be a morning object in Cygnus, 3° north of 3rd-magnitude Zeta (ζ) Cygni at the tip of the Swan's western wing, and 5° east of the Veil Nebula. The comet, possibly as bright as magnitude 0 or thereabouts, will be brighter than any of the objects around it and should rival or surpass Deneb, some 12° to its north-northeast. Hale-Bopp should drag a substantial tail — 5° to 10° or longer — by this time, which will easily distinguish it from surrounding stars. Unfortunately, the Moon that was full on February 22, will be brightening the sky and detract somewhat from the comet's overall splendor — although not to the point where comet-watchers will feel inclined to sleep in every morning!

Traveling to the northeast at the rate of approximately 1½° per day, Comet Hale-Bopp enters Lacerta on March 7. It can be found approximately 3° west of 4th magnitude 1 Lacertae. Meanwhile, the Moon will be in its 3rd quarter phase on the 2nd, and by the 7th will essentially have vanished from the morning sky, allowing the comet's tail to shine brightly. From my New Mexico home at a latitude of 33° north, the comet will rise more than 3½ hours before sunrise, and this time differential increases to five hours for those located at a latitude of 45°. Crisp, early March mornings allow plenty of opportunities for gazing in awe at this silent visitor from the outer solar system.

Unique Solar Eclipse Opportunity

New Moon occurs on March 9, and on that morning Hale-Bopp will be located approximately 1½° north of 1 Lacertae. It should be somewhere between magnitudes 0 and –1, a beautiful object in the predawn sky. Those comet-watchers who yearn to travel, and are willing to brave some cold temperatures, can witness an unusual sight that day: A total solar eclipse will be visible across Mongolia and a swath of eastern Siberia. Anyone standing in the path of totality should also see the comet, shining some 46° northeast of the eclipsed Sun. Such a sight — combining two of the most impressive phenomena in nature — is extremely rare. Less than half a dozen "eclipse comets" have been seen throughout recorded history; the last one in 1948.

toward its widely anticipated rendezvous with the Sun.


Tim Puckett

Visible as darkness fell in the November skies, Hale-Bopp nestled within the embrace of Ophiuchus, the legendary Serpent Holder. On November 9, 1996, Tim Puckett captured the comet for 5 minutes with an Axiom AX-7 CCD camera and a 30-cm reflector.

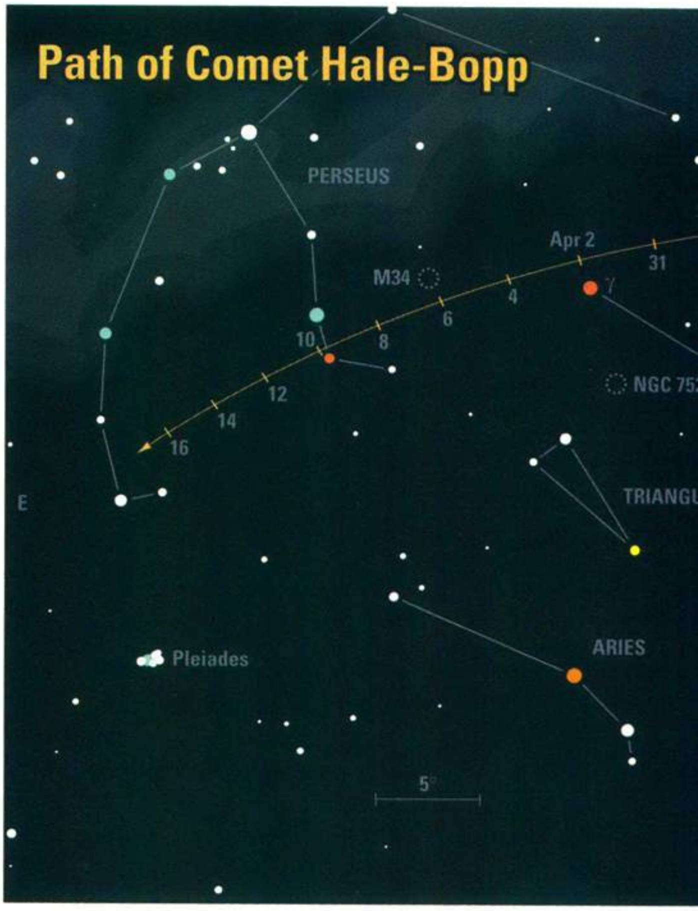
Potential eclipse chasers should be prepared for cold weather. Even in Mongolia, the expected temperatures at totality will range between 0° and 30° F, and the chance for clear viewing is 50-50. On the other hand, eclipse viewers in Siberia are almost guaranteed to have clear skies — with likely temperatures as cold as –40° to –60° F.

Hale-Bopp will begin to have the morning sky to itself, and there could be a noticeable day-to-day brightening and lengthening of its tail. On the morning of the 11th, it will be located 2° south of 4th magnitude 6 Lacertae, and on the 14th, it can be found a degree west of o Andromedae. By this time, its declination will be approximately 43°, and its direction of motion will essentially have turned almost due east. Because of this, comet watchers in more southerly lati-

Where to Find Comet Hale-Bopp

Date	R.A. (2000)	Dec.	Mag.
March 1	21h28.5m	34°10'	–0.9
March 4	21h46.8m	36°26'	–1.1
March 7	22h07.1m	38°38'	–1.2
March 10	22h29.8m	40°42'	–1.4
March 13	22h54.7m	42°32'	–1.5
March 16	23h21.8m	44°02'	–1.6
March 19	23h50.7m	45°07'	–1.7
March 22	00h20.7m	45°43'	–1.7
March 25	00h51.0m	45°49'	–1.8
March 28	01h20.7m	45°23'	–1.8
March 31	01h49.0m	44°30'	–1.7

Along with the date, this table provides the comet's position in **right ascension** and **declination** (epoch 2000.0), equivalent to longitude and latitude on the sky. The **magnitude** is a measure of the comet's brightness: the faintest stars visible to the naked eye glow at about magnitude 6, the brightest at about magnitude –1.5. The brighter the comet gets, the smaller the number.


Path of Comet Hale-Bopp

tudes will notice the comet sinking closer to the northeastern horizon as the days go by. Although Hale-Bopp still will still rise three hours before the Sun at mid-month, this time differential will start to shrink rapidly during the following two weeks. Because the comet is traveling so far north, more northerly viewers, such as those near latitude 45°, will see a larger time difference between comet-rise and sunrise — about 5½ hours at mid-month.

By March 15, Hale-Bopp will be in Andromeda, and on the morning of the 17th, it will pass 1½° north of the planetary nebula NGC 7662 (see "Observer's Challenge: The Blue Snowball" in this month's Almanac). A day-and-a-half later it will slip between the 4th-magnitude stars Lambda (λ) and Kappa (κ) Andromedae, passing only 30′ north of Kappa. Now a brilliant object close to magnitude –1 or possibly brighter, and perhaps with a gleaming dust tail 10° to 20° long, the comet should be a glorious sight in the northeast morning sky.

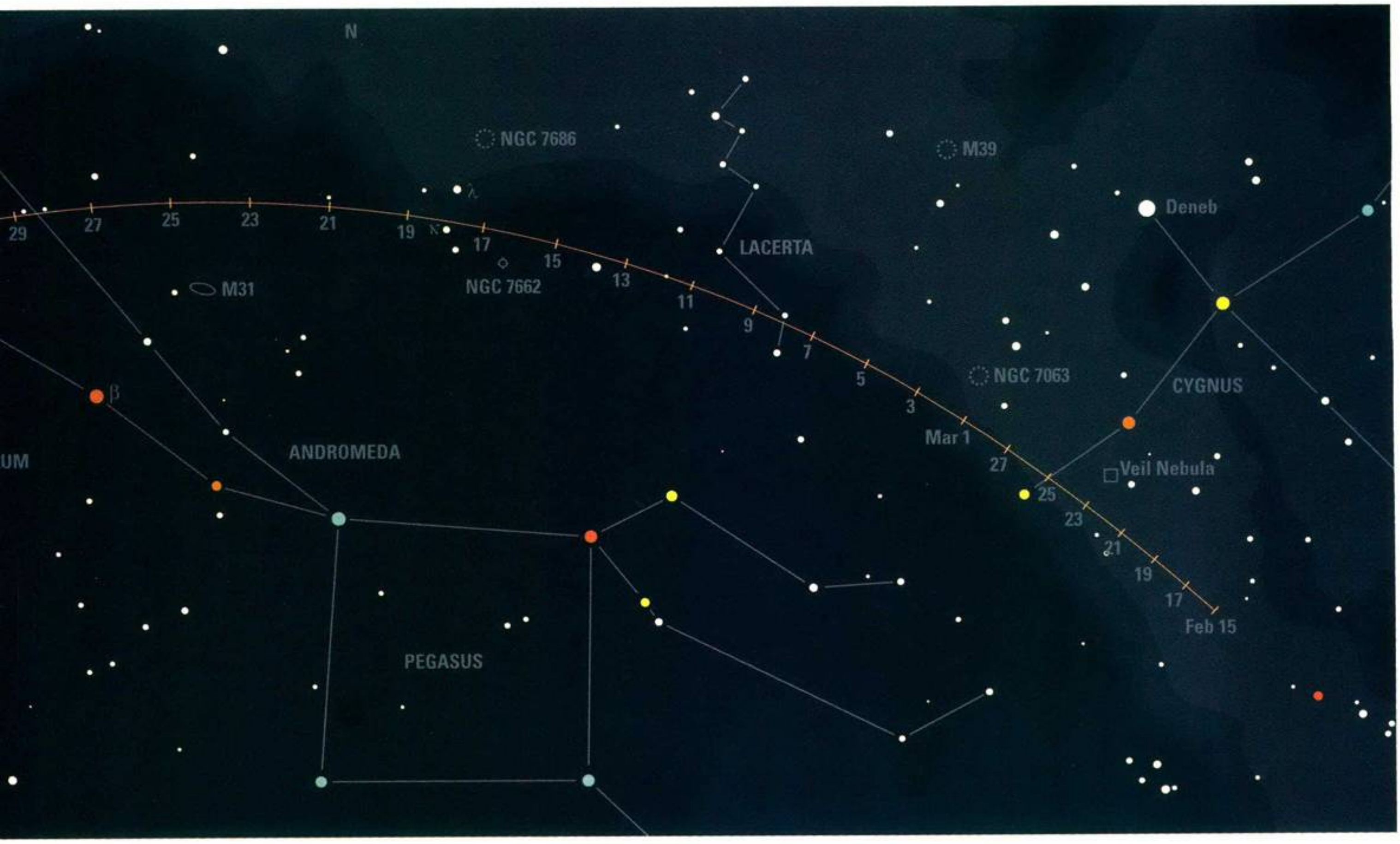
Due to the comet's declination of 45°, comet watchers in Canada and the northernmost United States will see it as a circumpolar object, skirting the northern horizon during the midnight hours. Viewers at my latitude won't have this view, but we may begin to see the comet low in the northwest during dusk, as well as during the morning hours.

On March 22, Comet Hale-Bopp will be in conjunction with the Sun, located 45° directly north of it. It will also be nearest the Earth on this date, 1.31 AU (122 million miles) away from our planet. Now located in central Andromeda some 5° east of Kappa Andromedae, it will not be an especially easy object to see from more southern latitudes. It will be visible close to the horizon both in the northwest at dusk and in the northeast at dawn. The further north one goes, the better the view, and anyone located north of latitude 44° will be able to see it near their northern horizon all night. Although its elevation above the horizon will remain fairly low regardless of where one is located, the comet's expected brilliance should render it easily visible, and the tail should be distinctly noticeable glowing against the northern stars.

Comet Circumpolar During Lunar Eclipse

Up until this point the Moon has been in the evening sky, conveniently out of the way for those who want to view the comet. The Moon will be full again on the evening of the 23rd, and ordinarily this would put a damper on observing the comet. But nature gives us a bit of a break; for a couple of hours that night, the Moon will plunge into the Earth's shadow, going into eclipse.

This eclipse will not be quite total, but it will be a deep partial so that the skies should permit a nice view of the comet. Mid-eclipse will be at 11:40 p.m. EST, so observers in the western United States are in a better position to take advantage of this event for viewing the comet. (On the other hand, anyone located far enough north to have the comet circumpolar from their location will be able to enjoy the dark sky spectacle.) At mid-eclipse, the comet will be



located in northern Andromeda some 5° northwest of the famous Andromeda Galaxy (M31).

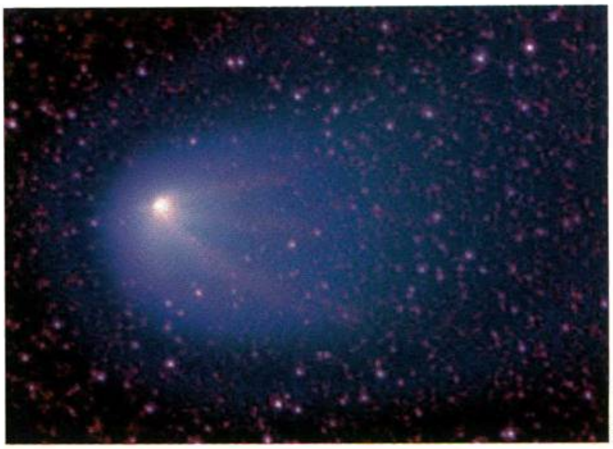
After that date, Comet Hale-Bopp will be technically an evening-sky object (although still visible low in the northeast during dawn), but by this time, the Moon will be conveniently a morning object, and once again we will be able to view the comet against a dark sky. On the evening of the 24th, it will pass 4½° due north of M31, presenting some interesting wide-field photo opportunities. (The comet, of course, should be much brighter than the galaxy.) Hale-Bopp will also be at its farthest north — just south of declination +46° — at this time, and afterward its motion will turn toward the southeast.

Nearing perihelion, Hale-Bopp could well be at its brightest during the last week of March, perhaps somewhere between magnitudes –1 and –2. During this period, it climbs rapidly into the northwestern evening sky, and by the end of the month it sets some 3½ hours after sunset, even at my latitude. It will be located in eastern Andromeda, forming an ever-changing triangle with the 2nd-magnitude stars Beta (β) and Gamma (γ) Andromedae, and will be 1½° south of 4th-magnitude Phi (ϕ) Andromedae on the evening of the 27th.

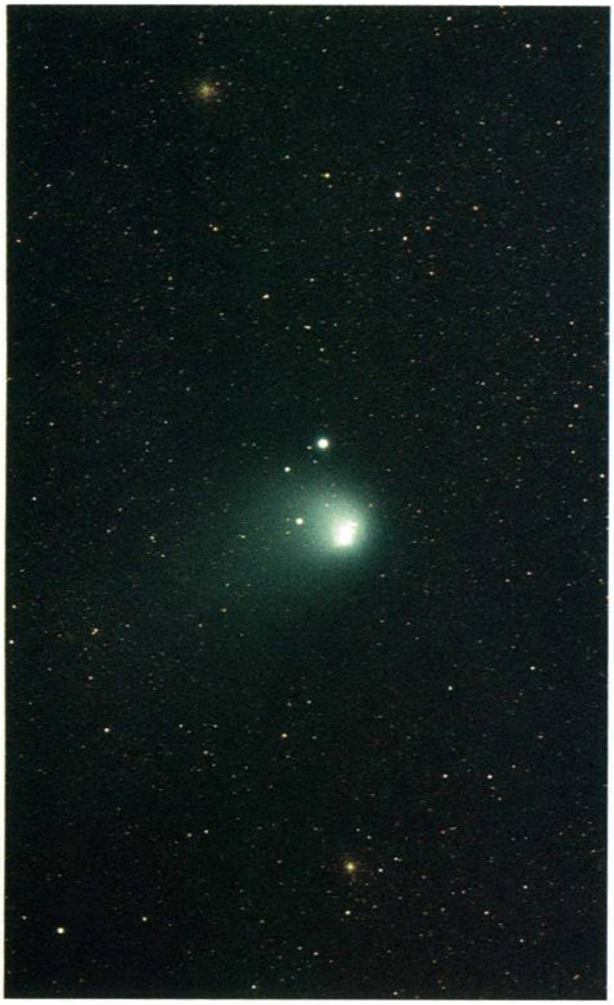
On the last day of the month, the comet will be some 4° northwest of Gamma (and two nights later, it will pass less than 1½° north of this colorful multiple star). Throughout this period, Comet Hale-Bopp should be an awesome sight in the evening sky, a show not to be missed.

Some Projects To Try

The month of March promises to be an exciting time for professional astronomers and amateur comet-watchers alike. The wealth and variety of activity we have already seen suggests that we should be prepared for just about anything as the comet experiences the Sun's heat in the inner solar system. Almost certainly, we will have a few surprises in store for us as we watch Hale-Bopp begin its final approach and then passage around the Sun.


Richard Berry

Easily distinguished from the glittering backdrop of stars, Hale-Bopp was an obvious naked-eye jewel on October 7, 1996. Using a Cookbook 245 CCD camera, Richard Berry made 20 integrations of 60 seconds each with his 6-inch f/5 Newtonian.



Chris and Carl Weber III

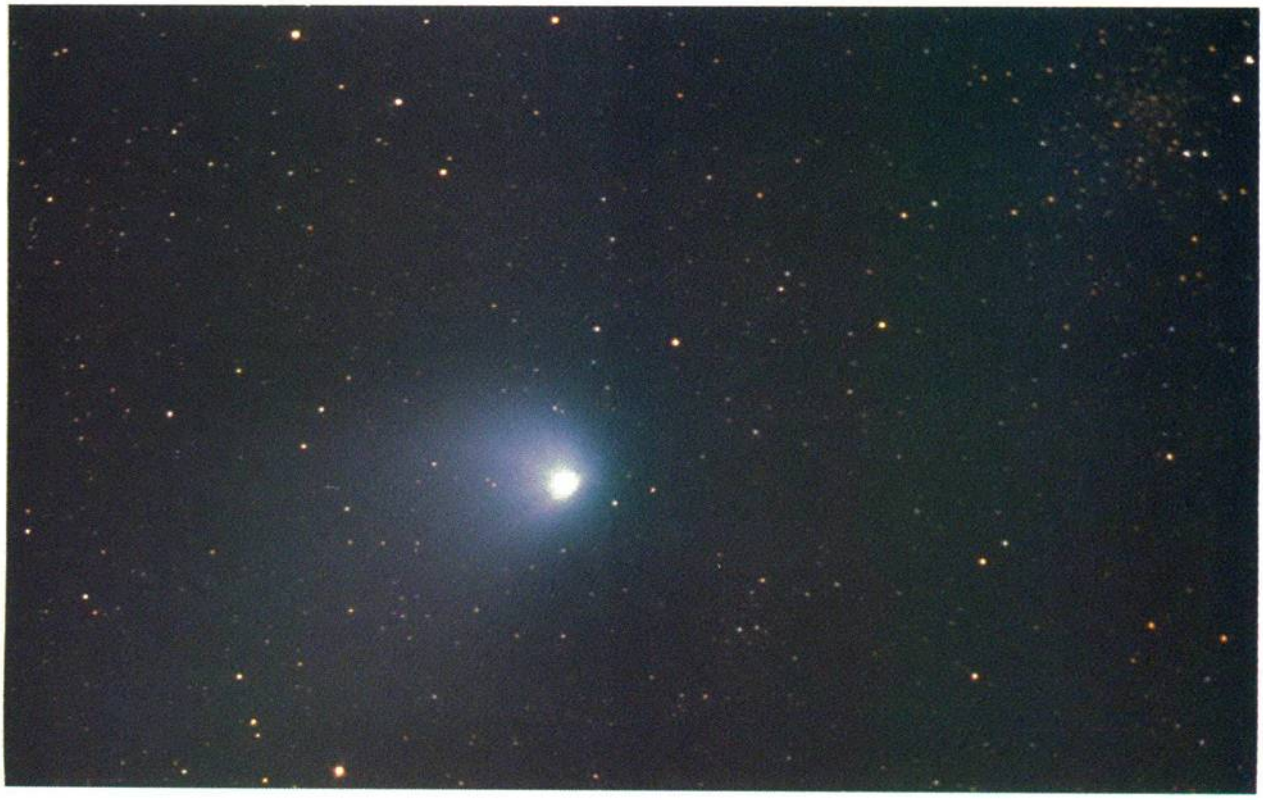
Silent sentinels in Ophiuchus, NGC 6517 and NGC 6539 seem to stand guard as Hale-Bopp glides between them and ever deeper into the snake handler's den. This photo was made on August 6, 1996, with a 6-inch f/7 EDF refractor, hypered Kodak PPF Pro 400 film, and a 45 minute exposure.

Consider trying one or more comet projects. You might observe the comet regularly to see how its brightness compares with the rough predictions I have given. Observations of the comet's physical structure — the length and structure of its tail (or tails), activity within the coma, and so on — will be especially worthwhile and could help scientists learn more about this object and about comets in general. Some specific things to look for might include: the way jets form and change within the inner coma, disconnection events in the tail, and sudden increases in brightness that might be indicative of fragmentation in the nucleus.

Photographing Hale-Bopp

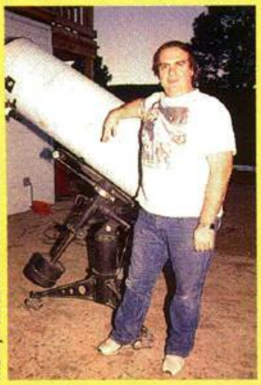
In addition to observing the comet, many Hale-Bopp watchers will probably want to take photographs of this visitor, and with the film and photography equipment available today you should be able to take some lovely images of the comet with a relatively simple set-up (see "Choosing the Right Film

Hale-Bopp got a unique chance to shine brightly during a Full Moon eclipsed on September 26, 1996. NGC 6366 shares the stage in the upper right of this photo during totality. The photo was made with a 12.5-inch f/5 Newtonian and a 20-minute exposure on Kodak PPF Pro 400 film.



Chris Schur

Catching a Comet

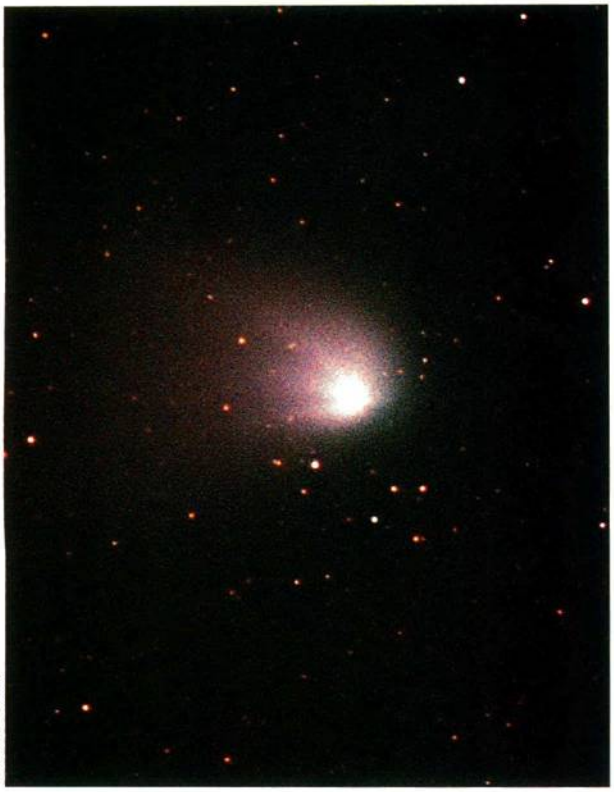

Marilyn Haddrill

Saturday night, July 22-23, 1995, started off as an ordinary night, except that it was clear. This is unusual because summer is the rainy season in southern New Mexico. I went outside sometime after 11:00 p.m. to observe the two comets I had been following. I had finished with the first one — Comet Clark, then a dim object of 12th magnitude — just before midnight. The other comet — Comet d'Arrest, then about 10th magnitude — wouldn't rise above my house for another hour or more, so I had some time to kill. The night was exceptionally beautiful. The Milky Way arched overhead shining brightly in Sagittarius high in the south, and I decided to pass the time by re-observing some old and familiar deep-sky objects in that part of the sky.

I began by looking at the globular cluster M70. However, as soon as I had it in my telescope's field of view, I noticed a dimmer, fuzzy object nearby. Since I had looked at M70 a couple of weeks earlier and hadn't noticed anything in this location, my suspicions were immediately aroused. I spent the next hour checking star atlases, deep-sky catalogs, and the IAU's list of known comets, coming up negative each time. After that hour I was able to tell that the object had moved against the background stars. I knew then I had found a new comet. The comet was found almost simultaneously, and in a similar manner, by Thomas Bopp of Glendale, Arizona, and it was announced to the astronomical world on the following afternoon via an *IAU Circular.*

Beginning with my high school days in the 1970s, I had spent several hundred hours hunting for new comets, but I never met with success. By the early 1990s I had become discouraged and I essentially gave up the search. Hunting for comets was far from my mind when I came across that fuzzy object near M70 that morning, and I can only feel a strong sense of irony that, having quit the search, I should finally find one. And, not just any comet — one with the potential for going down in history.

—Alan Hale


Michael Stecker

Steadily gaining on the Sun, Hale-Bopp sped through Ophiuchus during brisk October evenings. Michael Stecker photographed the comet on October 12, 1996 with a 6-inch f/7 Astrophysics refractor for 15 minutes on Fujicolor Super G 800 Plus film.

For Hale-Bopp," page 78). Those observers with CCD equipment will be able to capture highly detailed and scientifically useful images of the inner coma throughout the comet's entire period of visibility.

We should be able to entice our non-astronomical friends and neighbors to join us in watching this comet. In early March, this might be a bit difficult; the average person could be less than enthusiastic about getting up before dawn on chilly mornings. But at the end of the month, by which time Hale-Bopp will have entered the evening sky and should be near its brightest, almost everyone should be willing to take a look at this distant celestial wanderer. We who love the sky should take this opportunity to share a bit of the universe with our fellow citizens of planet Earth. ☐

Alan Hale is a co-discoverer of Comet Hale-Bopp. He is the founder and director of the Southwest Institute for Space Research in Cloudcroft, New Mexico, an organization devoted to astronomical research and education.

SKY ALMANAC

Comet Hale-Bopp and Mars shine at their brightest, while the Moon ushers in spring by digging deep into Earth's shadow to undergo a partial lunar eclipse.

by Martin Ratcliffe

The waiting's finally over for comet buffs worldwide. For the better part of 1½ years, they've been following a brightening patch of light called Comet Hale-Bopp with all the anticipation of children on Christmas Eve. This month marks the arrival of a metaphorical Christmas morning.

Hale-Bopp is drawing closer to the Sun, on track for a perihelion pass on April 1. During March, its nucleus comes alive in the Sun's warmth to dump tons of gas and dust each second into a tail millions of kilometers long. If predictions hold, Comet Hale-Bopp will become more and more alluring as March unfolds.

If you are just beginning an exploration of the night sky, you may be wondering what all the fuss is about. Well, bright comets like Hale-Bopp are quite rare. Comet West put on a spectacular display in 1976 for observers fortunate enough to enjoy clear skies during late winter. And in 1986, much-ballyhooed Comet Halley looked downright disappointing for most Northern Hemisphere observers.

Since then, nothing measured up as a quintessential bright comet until last year's appearance of Comet Hyakutake.

When Hale-Bopp was discovered well beyond the orbit of Jupiter in July 1995, astronomers knew they had an exceptional comet. First of all, Hale-Bopp was unusually active for a comet at that distance.

Second, its physical size was enormous. Hale-Bopp's nucleus of dirty ice measures between 30 and 40 kilometers, more than three times the size of most other comets.

Over the ensuing year and a half, Hale-Bopp has been keeping in line with brightness predictions, if not slightly fainter. This means it should not fizzle

Highlights
by Alister Ling

Date	Event
6	Jupiter Rules the Trees .....(p. 67)
16	A Red Planet and Its Opposition ....(p. 70)
17	**Observer's Challenge:** The Blue Snowball .....(p. 69)
23	A Vernal Lunar Eclipse ....(p. 70)
all month:	Mercury's Fleet-Footed Moment........(p. 67)
	Fleas on the Lion's Back.....(p. 68)
	First Views: Let Hale-Bopp Be Your Tour Guide .....(p. 71)

Tom Diana

This month Comet Hale-Bopp will look a lot like its famous cousin Comet Hyakutake, pictured here just about a year ago. The Sun's warmth boosts activity on the comet's nucleus of dirty ice, which blasts more dust into space to reflect yellow sunlight.

1997
MARCH

2 Last quarter Moon is at 4:37 a.m. EST

5 The Moon passes 4° north of Neptune, 3 p.m. EST

6 The Moon passes 5° north of Uranus, 4 a.m. EST
The Moon passes 5° north of Jupiter, 9 a.m. EST (page 67)

7 Asteroid Hebe is at opposition

8 The Moon is at perigee (357,758 kilometers from Earth), 4:02 a.m. EST
New Moon is at 8:15 p.m. EST; total solar eclipse

10 The Moon passes 1.4° north of Saturn, 4 a.m. EST

11 Mercury is in superior conjunction, 11 a.m. EST

14 The Moon passes 0.5° north of Aldebaran, 2 p.m. EST

15 First quarter Moon is at 7:06 p.m. EST

17 Mars is at opposition, 3 a.m. EST (page 70)

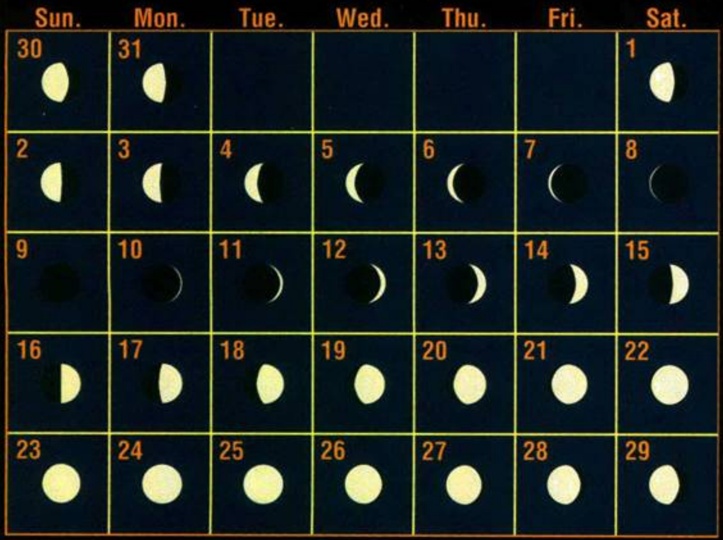
20 Vernal equinox is at 8:55 a.m. EST
Mars is closest to Earth (98.6 million kilometers away), noon EST
The Moon is at apogee (405,958 kilometers from Earth), 6:40 p.m. EST

22 Comet Hale-Bopp passes closest to Earth (197 million kilometers away) (page 71)

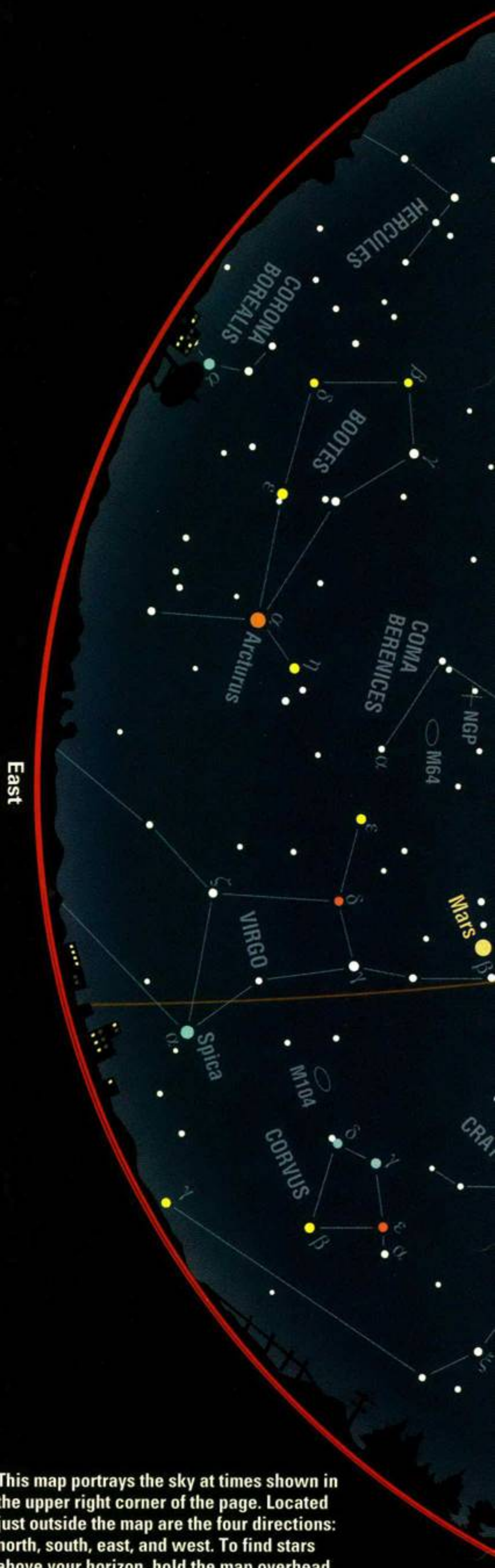
23 The Moon passes 4° south of Mars, 9 a.m. EST
Full Moon is at 11:45 p.m. EST; partial lunar eclipse (page 70)

30 Saturn is in conjunction with the Sun, 5 p.m. EST

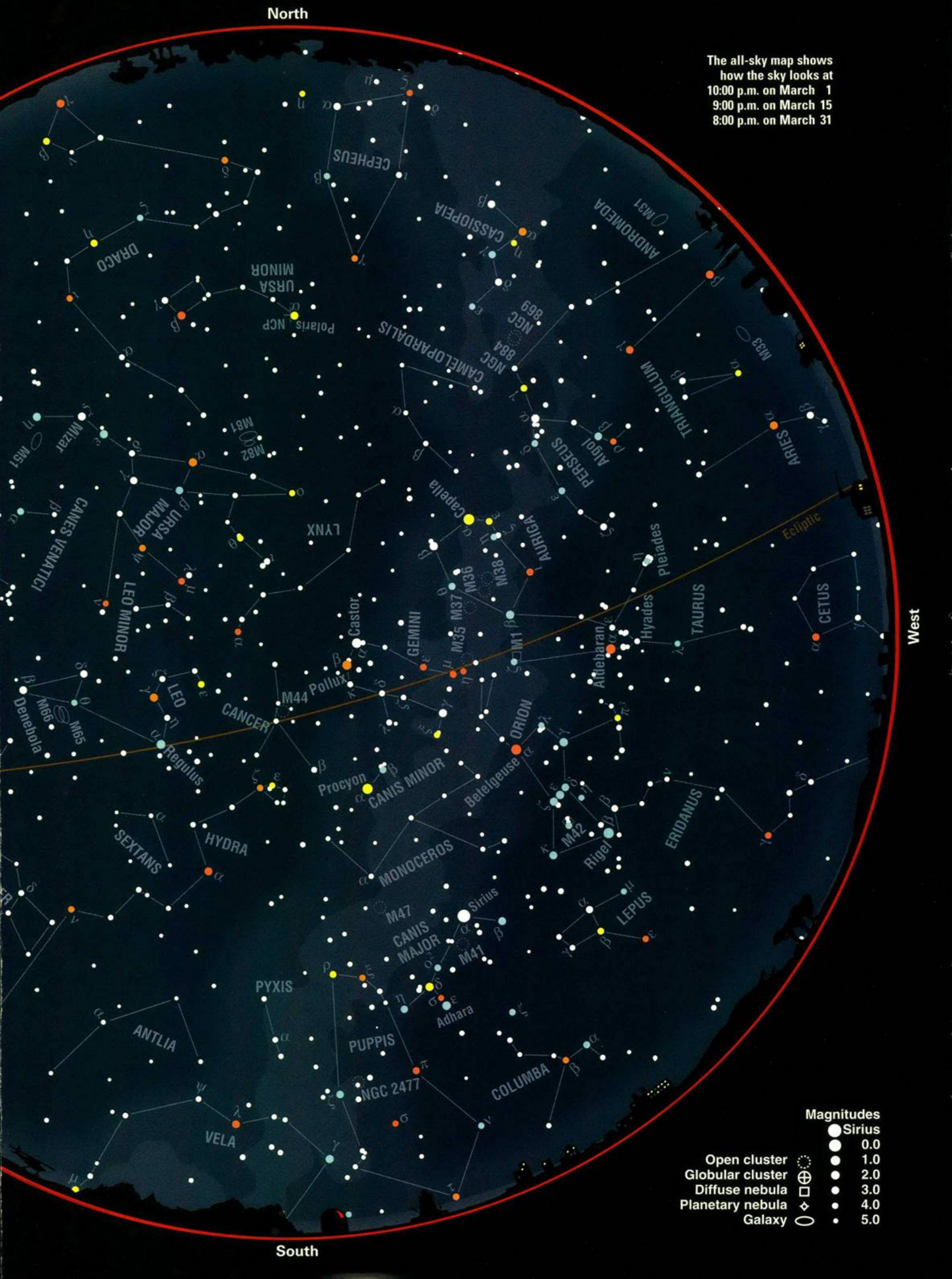
31 Last quarter Moon is at 2:38 p.m. EST



Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
30	31					1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29



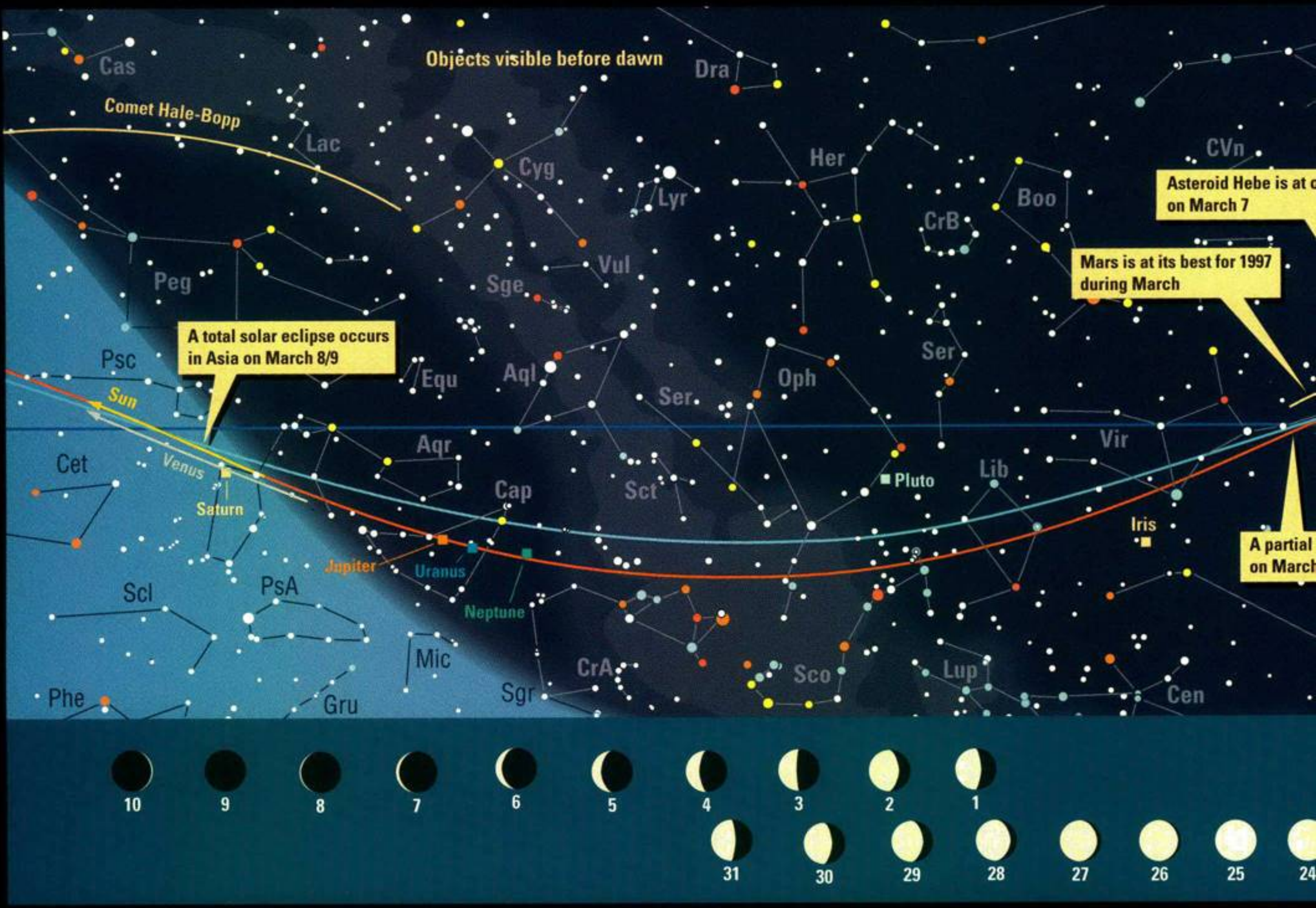
This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.



The all-sky map shows
how the sky looks at
10:00 p.m. on March 1
9:00 p.m. on March 15
8:00 p.m. on March 31

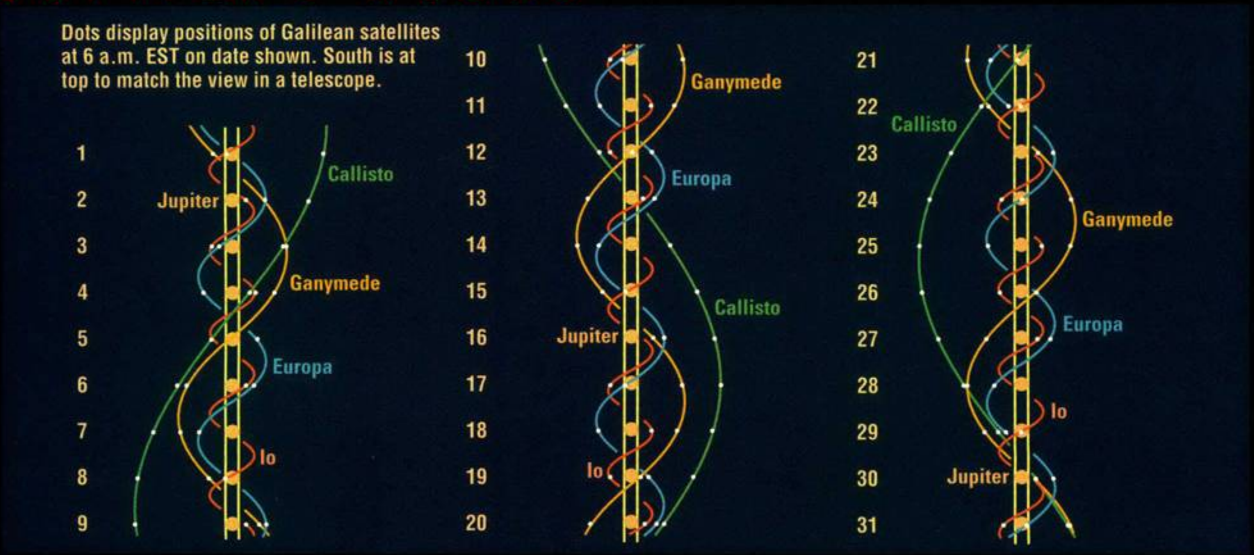
North
CEPHEUS
CASSIOPEIA
ANDROMEDA
M31
DRACO
URSA MINOR
Polaris
NCP
CAMELOPARDALIS
NGC 869
NGC 884
M33
TRIANGULUM
ARIES
PERSEUS
Algol
M81
M82
Mizar
M51
URSA MAJOR
CANES VENATICI
LYNX
Capella
AURIGA
Pleiades
Ecliptic
M36
M38
M37
M35
M1
TAURUS
CETUS
West
LEO MINOR
GEMINI
Castor
Pollux
Hyades
Aldebaran
M44
CANCER
LEO
Denebola
M66
M65
Regulus
ORION
Betelgeuse
Procyon
CANIS MINOR
ERIDANUS
SEXTANS
HYDRA
MONOCEROS
M42
Rigel
M47
Sirius
CANIS MAJOR
M41
LEPUS
PYXIS
Adhara
ANTLIA
PUPPIS
COLUMBA
NGC 2477
VELA
South
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

THE PATH OF THE PLANETS

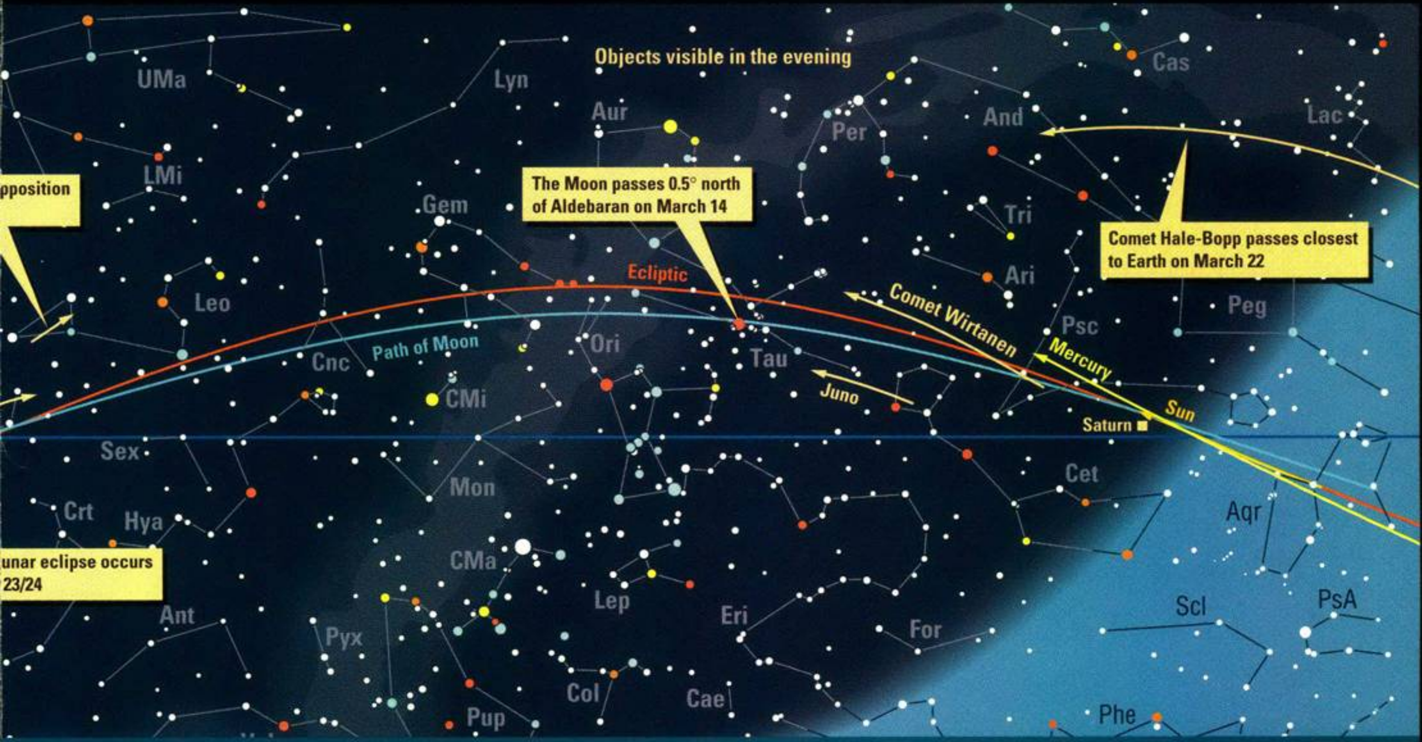

Objects visible before dawn
Cas
Comet Hale-Bopp
Lac
Dra
Cyg
Lyr
Her
CVn
Asteroid Hebe is at o
on March 7
Boo
CrB
Peg
Sge
Vul
Mars is at its best for 1997
during March
A total solar eclipse occurs
in Asia on March 8/9
Psc
Sun
Equ
Aql
Ser
Oph
Ser
Cet
Venus
Saturn
Aqr
Cap
Sct
Pluto
Lib
Vir
Iris
A partial
on March
Jupiter
Uranus
Neptune
Scl
PsA
Mic
CrA
Sco
Lup
Cen
Phe
Gru
Sgr
10
9
8
7
6
5
4
3
2
1
31
30
29
28
27
26
25
24

10" PLANETS	MERCURY	MERCURY	VENUS	MARS
Date	March 1	March 31	March 15	March 15
Magnitude	−0.9	−0.7	−3.9	−1.3
Angular Size	4.9"	6.5"	9.7"	14.1"
Illumination	96%	64%	100%	100%
Distance (AU) from Earth	1.371	1.040	1.713	0.663
Distance (AU) from Sun	0.424	0.312	0.728	1.656
Right Ascension (2000.0)	22h17.2m	1h40.6m	23h24.8m	11h57.5m
Declination (2000.0)	−12°56'	12°15'	−5°22'	4°20'

JUPITER'S MOONS



Dots display positions of Galilean satellites at 6 a.m. EST on date shown. South is at top to match the view in a telescope.

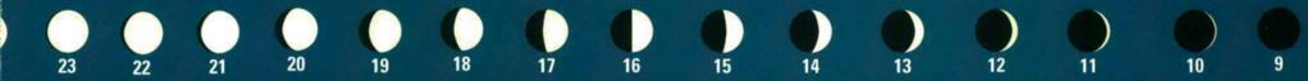

Objects visible in the evening
UMa
Lyn
Aur
Per
Cas
And
Lac
LMi
Gem
Tri
Ari
Leo
Ecliptic
Comet Wirtanen
Psc
Peg
Path of Moon
Cnc
Ori
Tau
Mercury
CMi
Juno
Sun
Saturn
Sex
Mon
Cet
Aqr
Crt
Hya
CMa
Lep
Eri
For
Scl
PsA
Ant
Pyx
Col
Cae
Pup
Phe

pposition

The Moon passes 0.5° north of Aldebaran on March 14

Comet Hale-Bopp passes closest to Earth on March 22

unar eclipse occurs
23/24


23
22
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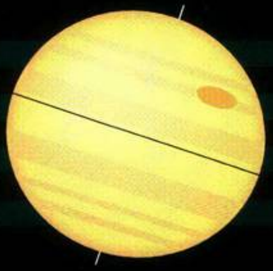
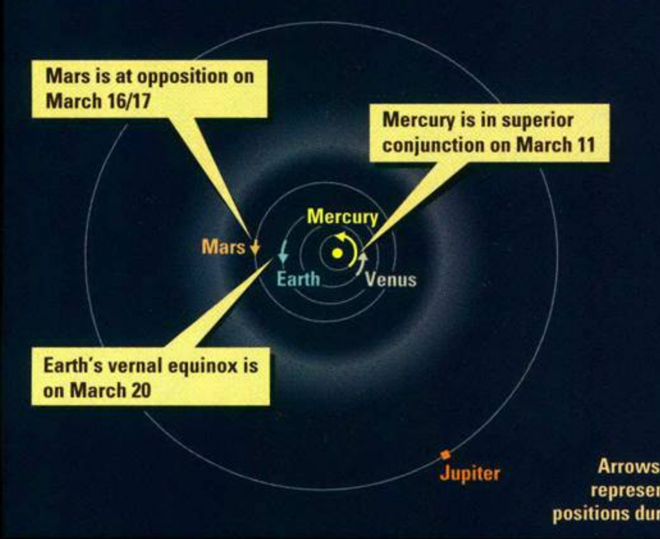
9

JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
March 15	March 15	March 15	March 15	March 15
–2.0	0.8	5.9	8.0	13.7
34.0"	16.0"	3.4"	2.2"	0.1"
100%	100%	100%	100%	100%
5.798	10.412	20.470	30.712	29.635
5.112	9.450	19.807	30.154	29.964
20h57.6m	0h34.0m	20h39.6m	20h05.8m	16h23.9m
–17°42'	1°17'	–19°00'	–19°52'	–8°40'



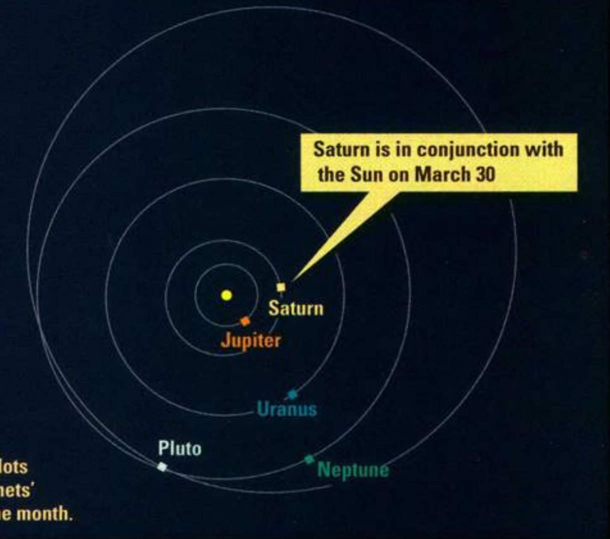
THE PLANETS IN THEIR ORBITS


Mars
Mercury
Earth
Venus
Jupiter

Mars is at opposition on March 16/17

Mercury is in superior conjunction on March 11

Earth's vernal equinox is on March 20


Saturn
Jupiter
Uranus
Pluto
Neptune

Saturn is in conjunction with the Sun on March 30

Arrows and dots represent planets' positions during the month.

like Comet Kohoutek did in 1973. (Kohoutek was also discovered far away from the Sun, but a thin veneer of volatile material made it active for only a short time.)

Against this backdrop of great expectations, skywatchers have been holding their collective breath for the coming of March 1997. For March is the time to view Hale-Bopp as it zeros in on the Sun.

Predictions indicate it might get as bright as Orion's Rigel; overall luminescence might even exceed Sirius, the brightest star in the sky. (These brightness estimates apply to Hale-Bopp's integrated magnitude, which takes the comet's brightness spread over several degrees of sky and condenses it into a theoretical point of light.)

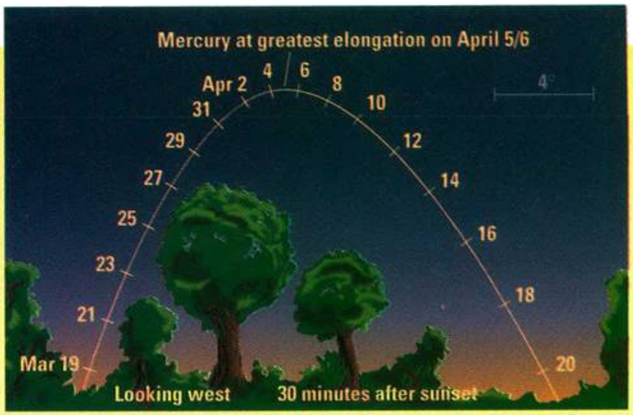
If indeed the comet glows as hoped, it will be a conspicuous object in the evening sky, in the northwest after sunset from midmonth onwards. It will continue to brighten later in the month, so many people should get a chance to see it, perhaps even while making the evening commute home from work.

If you can't wait until midmonth, rise in the early morning hours during the first week of March to spot Hale-Bopp high in the northeast before sunrise.

Remember — a comet's most delicate feature is its tail. If you have any stray light around you, the gossamer tail will remain elusive. The best views will come at dark sites. At its brightest, Hale-Bopp's tail will project from the horizon like a misty searchlight among the stars.

Because comets have tails, many people think they streak across the sky. Ages ago, comets were thought to originate in our

Mercury's Fleet-Footed Moment



All illustrations by Astronomy: Elisabeth Rowan

Fleet-footed Mercury puts on a fine evening show during March and April, its best display of 1997. From our earthly point of view, the innermost planet never strays far from the Sun. Get a good look near its greatest elongation from the Sun, which happens on April 5/6.

A little solar system geometry helps the visibility of Mercury this spring. During the Northern Hemisphere springtime, the ecliptic — a line along which all the planets appear to travel through the sky — makes a steep angle to the western horizon in the evening. This translates Mercury's distance from the Sun into altitude above our horizon. The farther Mercury gets from the Sun this time of year, the higher it stands in the west after sunset.

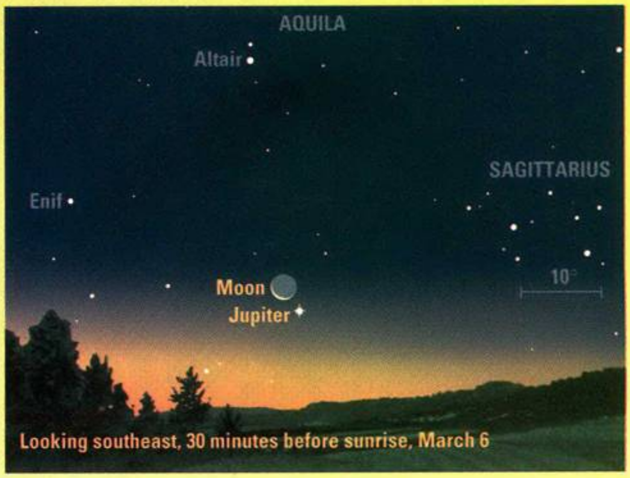
Start scanning just above the horizon about an hour after sunset with a pair of binoculars. Mercury will be the only bright object in that area of sky, so identification will be a snap.

Once you find the planet in binoculars, try spotting it with the unaided eye. A telescope will reveal a tiny 6"-diameter gibbous disk, a phase our Moon displays just a couple of days after full. — *A. L.*

Jupiter Rules the Trees

All during March, just before daybreak, blazing Jupiter commands our attention from a star-poor area of the sky. Look for a bright, steady, peach-colored beacon low in the southeast before sunrise.

Because Jupiter's so low in the morning air, its brightness might twinkle a myriad of colors to mimic some sort of strange light.



Looking southeast, 30 minutes before sunrise, March 6

Be prepared to explain to your coworkers that the bright light they saw low in the southeast while commuting to work that morning was not a plane or a UFO, but a giant planet where NASA's Galileo orbiter is taking some amazing pictures.

If you have access to a telescope, try following the ballet of Jupiter's four bright, large moons. Their orbits around Jupiter cause them to shift position relative to one another from one morning to another. The line-up is always different.

Morning is also the best time to try some scenic photography with Jupiter. The best scene this month is on the morning of March 6, when a thin, waning crescent Moon lies less than 5° to the north of the bright planet. Find a place with a nice line of trees or a church steeple, then set up your camera on a tripod and shoot.

Use exposures one to two speed settings faster than what the camera's light meter recommends. If your camera is fully automatic, underexpose by one or two settings. Of course, share your results with Astronomy. — *A. L.*

atmosphere, an illusion created by a comet's appearance.

We now know that they lie millions of miles from Earth and move very slowly against the starry background in long, elliptical orbits around the Sun that keep them largely in a deep freeze, sometimes, as in Hale-Bopp's case, for many thousands of years.

But as a comet nears the warm fires of the Sun, a coma develops and clouds of gas and dust expand into the vacuum of space.

The pressure of sunlight itself blows this dust back away from the comet's head to form a tail. This tail always points away from the Sun like a giant windsock.

After rounding the Sun, the bright tail slowly shrinks as the icy nucleus cools into dormancy until the next trip near the Sun.

In addition to an awakened comet, the March night sky offers many other interesting sights. To begin with, there are all the deep-sky objects Hale-Bopp passes, all worthy of checking out during your comet watching (see the First Views project box).

Then on March 23/24 there's a partial lunar eclipse, the best for North America until the year 2000. The event appropriately rings in spring for the Northern Hemisphere, which arrives on March 20 at 8:55 a.m Eastern Time. Three days later, the Moon obligingly takes a springtime dip into Earth's shadow.

Although only a partial, it is a major one; 92% of the Moon digs into Earth's shadow. The event begins at 9:58 p.m. EST and reaches maximum at 11:39 p.m. EST.

The Moon's pass into our planet's shadow is deep enough for us to see some color in the darkened portion. Most of the Moon will look reddish under the light created by Earth's sunrises and sunsets occurring simultaneously. However, the northern edge of the Moon should remain as a bright sliver. The last part of Earth's dark shadow quits the Moon at 1:21 a.m. EST on March 24.

Many observers enjoy eclipses because of the fainter objects they can see while the Moon's light is diminished. One sight you won't want to miss is Hale-Bopp's tail. If the comet is bright enough and you have a clear north vantage, you could spot what looks like a shaft of light pointing away from the Sun, which is below your horizon. Observers viewing north of latitude 47° might even glimpse the comet's head about 3° above the horizon.

This month's eclipse takes place in Virgo, which is also home to **Mars** this spring. The Red Planet lies 10° northwest of the Moon on eclipse night, having reached opposition a week earlier on March 17.

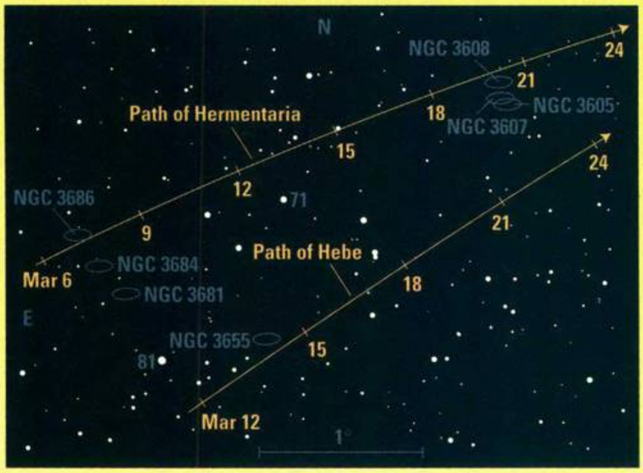
At that time, Mars was geometrically opposite the Sun in our sky. During March it shines at its brightest in more than two years, almost as bright as Sirius, at magnitude –1.3. Like the full Moon, Mars rises at sunset, lies due south at midnight, and sets during sunrise.

Mars reaches an apparent size of 14.2" during this opposition, its largest apparent size since January 1993. But this is still only half the size of a moderately sized crater on the Moon viewed through a telescope.

Because of this, observing Mars requires patience. Fleeting moments of still air will yield wonderful, detailed views. Look for the remnants of a north polar cap, which is angled toward us at this apparition. Watch for changes in its size over the next few weeks.

This month also sees Mars well into what's called a retrograde loop. This happens when Earth, moving in a faster orbit

Fleas on the Lion's Back



Two medium-sized asteroids trek in front of the galaxies of central Leo this month, at times traveling in apparent formation through the same field of view.

The interlopers differ considerably: 6 Hebe is a respectable 190 kilometers (120 miles) across shining at magnitude 9.6, while 346 Hermentaria is almost half Hebe's size and glows more feebly at magnitude 11.8.

Three relatively bright galaxies, all visible in an 8-inch telescope, provide a backdrop for identifying Hermentaria on the nights of March 6, 7, 8, and 9. From north to south, NGCs 3686, 3684, and 3681 lie within the same 100x field of view. On the night of March 7/8, the asteroid slips 4' south of magnitude-11.4 NGC 3686.

Just about 10 days later, Hermentaria rushes toward what I call the Leo Trio, NGCs 3605 (magnitude 12.3), 3607 (9.9), and 3608 (10.8). The asteroid passes just north of NGC 3608 on the night of March 19/20, competing with the light of a nearby waxing Moon.

Hebe makes its own encounter with a galaxy on March 13/14, when it scrapes a mere 2' past the round 11.7-magnitude spiral galaxy NGC 3655. A waxing crescent Moon will also hamper your view of the galaxy, but for those who use bigger scopes, the view's still worth a glimpse.

By the time of March 23's partial lunar eclipse, Hebe lies south and west of the Leo Trio, while Hermentaria is to the northwest. Check them out under the dark of an eclipsed Moon. — *A. L.*

around the Sun, overtakes a planet that's farther from the Sun.

In the Red Planet's case, its normal easterly path among the stars gets reversed to a westerly direction against Virgo and Leo until the end of April.

We see this retrograde effect in everyday life when we pass a slower-moving vehicle on a highway. Relative to you, the other car moves backwards, or in technical parlance, in retrograde.

Mars' retrograde motion this month takes it north of Beta (β) Virginis, which lies below the tail of Leo the Lion.

When they're not playing host to eclipses and planetary visitors, Leo and Virgo are fine constellations to get to know better. Not only do they harbor fine double stars — Porrima (γ Virginis) in Virgo and Algieba (γ Leonis) in Leo — but numerous distant galaxies as well. Many of these island universes are easy targets through small telescopes under dark, moonless skies.

Two fine 9th-magnitude spiral galaxies, M65 and M66, lie in the same low-power field of view midway between Theta (θ) and Iota (ι) Leonis.

Farther west, M95 and M96 lie under the Lion's midriff, a little less than 7° east of Regulus. Just under a degree to the northeast, the elliptical galaxy M105 completes this trio to make for one of the finest deep-sky views in the heavens.

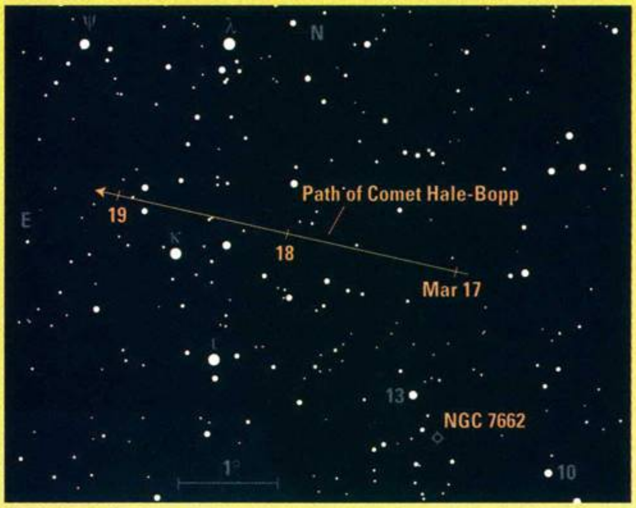
Virgo is also home to more than a dozen Messier objects. Some have been made famous over the years due to their curious nature.

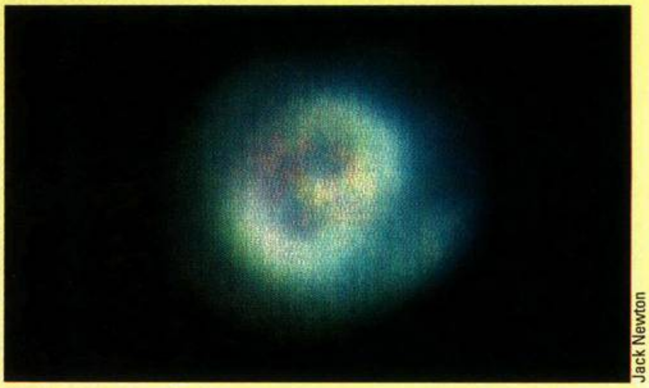
One is M87, a magnitude-8.6 elliptical galaxy that sports a bright jet extending from its core. The jet isn't easy to spot in most backyard telescopes, but the feature has been imaged by astronomers for many years.

Scientists have long thought the jet is material squirted out by a black hole that lies in the center of M87. The Hubble Space Telescope confirmed this by measuring the motion of material spinning around M87's nucleus.

This finding alone places this galaxy high on the observing lists of many deep-sky aficionados.

Observer's Challenge: **The Blue Snowball**




Jack Newton

On the morning of March 17, Hale-Bopp passes 1.6° north of one of the sky's least-observed, bright planetary nebulae: NGC 7662, the Blue Snowball. The Moon will have set by 2 a.m., leaving the sky dark — perfect for seeing the comet's tail and tracking down this under-appreciated planetary.

To find the Blue Snowball, simply drop two low-power fields south of Hale-Bopp on March 17. On other nights, without the comet to guide you, use an interesting Y-shaped group of stars — Iota (ι), Kappa (κ), Lambda (λ), and Psi (ψ) Andromedae — as a starting point just over 2° to the northeast. From Iota, slide two or three low-power fields of view west. The Snowball's position in Epoch 2000 coordinates is 23h 25.9m, 42°33'.

You'll find that NGC 7662 is even brighter than its famous cousin, the Ring Nebula (M57) in Lyra, but smaller, about ⅓ the size.

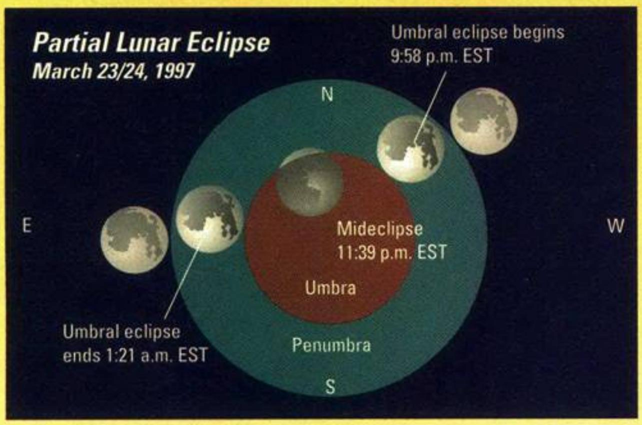
Low power in even a small scope will reveal the Snowball is a really odd-looking star. Try an experiment under higher magnification: Make the nebula seemingly disappear by looking straight at it. This "winking out" is caused by a lack of rods in the central region of your eye's retina. Shifting your glance off to one side — using what's called averted vision — causes the Blue Snowball to pop back into view.

This magnificent nebula's really high surface brightness lets it pierce through bright skies. But to see the Snowball's namesake blue color, you'll need the gathering power of a scope at least 12 inches in aperture.

Once you center the nebula in a medium- to high-power field of view, let its light "soak" your eye for several seconds to activate color-sensitive cones. If you have access to dark skies and a large scope, look for the Blue Snowball's faint outer halo. A central hole and weak western edge are easier to pick off.

A planetary nebula is a shining gas cloud that signals the final act of a star's life. These objects were coined "planetary nebulae" by early observers who found them reminiscent of what Neptune and Uranus looked like through a telescope. — *A. L.*

A Vernal Lunar Eclipse



Thomas R. Perry

As people in the Northern Hemisphere rejoice the arrival of spring, the sky salutes them back with an eclipse on Sunday evening, March 23.

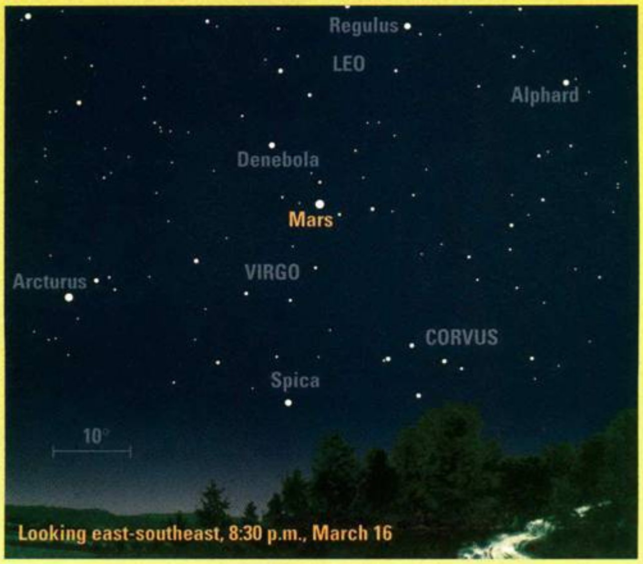
Although not a total one like last fall's extravaganza, this month's partial will be a spectacular event nonetheless. The Moon cuts so deep into Earth's shadow that at mideclipse it will display only a super-thin white eyebrow above an orange face.

Barring any volcanic eruptions that spew dust into Earth's atmosphere, the shadowed part of the Moon takes on a bright orange hue. The color will become apparent as more of the Moon's bright face slides into darkness.

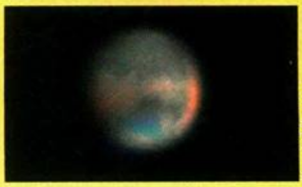
One simply cannot overstate the beauty of an eclipse in binoculars. Many onlookers say the Moon takes on a three-dimensional appearance in binoculars during the partial phases. Will the effect be noticeable during this month's eclipse? The sensation is less obvious during totality, so start observing early.

As the Moon's bright light gets extinguished, fainter stars will glimmer into view. Mars lies 10° away — compare its rusty color with the Moon's ruddy hue. And don't forget to look north for Comet Hale-Bopp's tail, which may wink into view close to the moment of mideclipse. — *A. L.*

A Red Planet and Its Opposition



Looking east-southeast, 8:30 p.m., March 16



Donald Parker

Align yourself with a brilliant red star as it rises in the east with Virgo the Virgin on March 16. At that moment you, it, and the Sun will form a straight line in space.

If you really feel ambitious, watch that red star all night. Note how this bright star rose at sunset, lies due south and is highest in the sky at local midnight, and sets at sunrise.

That bright star is actually Mars, and what you've just demonstrated is its opposition with Earth on the night of March 16/17.

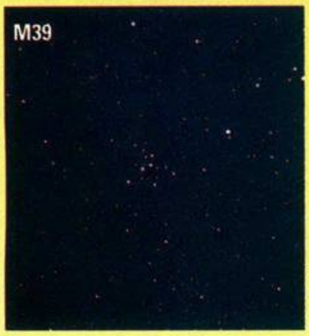
Planets that lie beyond Earth come to opposition when Earth lies directly between them and the Sun. For Mars, this last happened in February 1995. During opposition, Mars is at its brightest and largest through a telescope.

At 14" across — about ⅓ the apparent size of Jupiter's disk — the ocher orb presents us with a slowly rotating parade of darker (rougher areas on Mars that reflect less light) and lighter surface features (sandy areas).

The most obvious feature this opposition will be Mars' north polar ice cap. Because Mars is just entering northern hemisphere summer, the brilliant white cap will gradually shrink over the next few weeks. The easiest dark feature on Mars' surface is Syrtis Major, which has a shape similar to India.

For a complete primer on what to look for on Mars, turn to page 88 for "Your Guide to Observing Mars". — *A. L.*

First Views:
Let Hale-Bopp Be Your Tour Guide

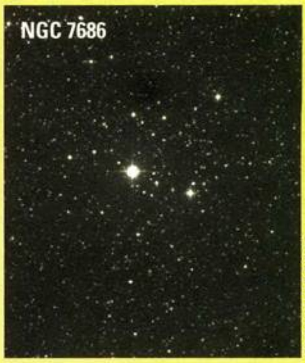


M39

F. A. Sudlow

NGC 7063

STScI/ NGS POSS



NGC 7686

STScI/ NGS POSS

NGC 752

J. Metcalfe

As we all follow and photograph Hale-Bopp this month, we'll run into some notable deep-sky targets along its path (see the map on page 58).

The first catch is the Messier star cluster M39 in Cygnus, an unmistakable, splashy group of white stars about two 7x50 binocular fields north of the comet's position in early March. Under dark skies, case out the area around M39 to enjoy the Milky Way's fine starry background and the ethereal presence of dark nebulae.

A little closer to Hale-Bopp's path during the first nights of the month lies the open star cluster NGC 7063. This sparse group of a dozen or so 10th-magnitude stars may even get covered by Hale-Bopp's tail. A small scope offers the finest view of this cluster.

By midmonth, Hale-Bopp slices right through a delightful Y-shaped group of stars in northern Andromeda. These point the way to the Blue Snowball (see this month's Observer's Challenge) and farther north to another star cluster, NGC 7686.

In late March, Hale-Bopp passes one binocular field of view north of the lovely star cluster NGC 752 in Andromeda. Look for the cluster's feeble glow with your naked eye under a dark sky as a misty patch of light. Binoculars will resolve it into two dozen stars.

Sidewalk astronomers sharing Hale-Bopp with the public should not miss pointing out two showpiece objects in Andromeda: M31, the Andromeda Galaxy and Gamma (γ) Andromedae, a gorgeous orange-blue double star.

Although not as splashy as the comet, the pair provides an opportunity to show people the wonder and immensity of the universe. M31 is best seen in the evening sky toward the end of the month, when the Moon rises much later. — *A. L.*

Somewhat less enigmatic are M59 (magnitude 9.8), and M60 (8.8), bright elliptical galaxies visible in the same low-power field of view. The pair lie just north of Rho (ρ) Virginis. For best views, wait until this area of the sky lies high in the south around midnight.

If your schedule doesn't allow for late-night observing, try the galaxies on show in early evening. Finest of them all is M31, the Andromeda Galaxy. At 2.2 million light-years away, it's the most distant thing you'll ever see with your naked eye. Look for it in the northwest after sunset in early March.

While you're in the neighborhood, check out M33 in Triangulum, which lies about the same distance from 2nd-magnitude Mirach (Beta [β] Andromedae) as does M31, but in the opposite direction. M33 is a face-on spiral galaxy of rather low surface brightness, detectable in binoculars and wonderful in a low power, rich-field telescope under dark skies.

Early March is also the time to catch your last view of **Saturn** before it descends into the bright evening twilight. A delicate crescent Moon lies near the Ringed Planet on March 9 and 10. Look quickly; Saturn reaches conjunction with the Sun on March 30.

March finds other planets teasing the Sun's glare. **Mercury**, lying on the far side of the Sun from Earth, passes superior conjunction on March 11 to pass into the evening sky. **Venus** is invisible as it closes in on a conjunction with the Sun early next month.

Unaffected by solar glare, **Pluto** rises shortly before midnight near the 5th-magnitude star Upsilon (υ) Ophiuchi.

Its faint glow can only be glimpsed in telescopes with mirrors larger than 8 inches. The 14th-magnitude planet is a challenge to spot, and will only get marginally brighter as its opposition approaches this spring.

Two other outer planets, **Neptune** and **Uranus**, rise during the early morning hours. Neptune comes up more than two hours ahead of the Sun and lies 2° north of the globular cluster M75 in Sagittarius. Uranus rises half an hour after Neptune to lie less than a degree south of 5th-magnitude Upsilon Capricorni.

Last to rise is **Jupiter**, the planetary godfather of them all. On the morning of March 6 a waning crescent Moon lies north of the giant planet. Both become visible about an hour before sunrise in the southeast.

Usually such a conjunction is a sight to behold in itself, but on that same morning another sight might steal the show. Hanging above the northeastern horizon just before sunrise is Comet Hale-Bopp. ☐

Martin Ratcliffe directs the Henry Buhl, Jr. Planetarium in Pittsburgh, Pennsylvania. Alister Ling is a meteorologist for Environment Canada in Alberta.

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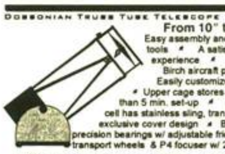

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Choosing The Rig

Comet Hale-Bopp won't be around forever, so make sure you choose the best film for your astrophotos.

Story and photos by Chris Schur

Comet Hale-Bopp is here. Skyshooters by the thousands will be out each night trying to capture the wonder of this visitor. To successfully record this historic event, the correct selection of both camera and film will be essential. The right film will accurately record the memory for years to come, the wrong choice can spell disappointment and an opportunity lost forever.

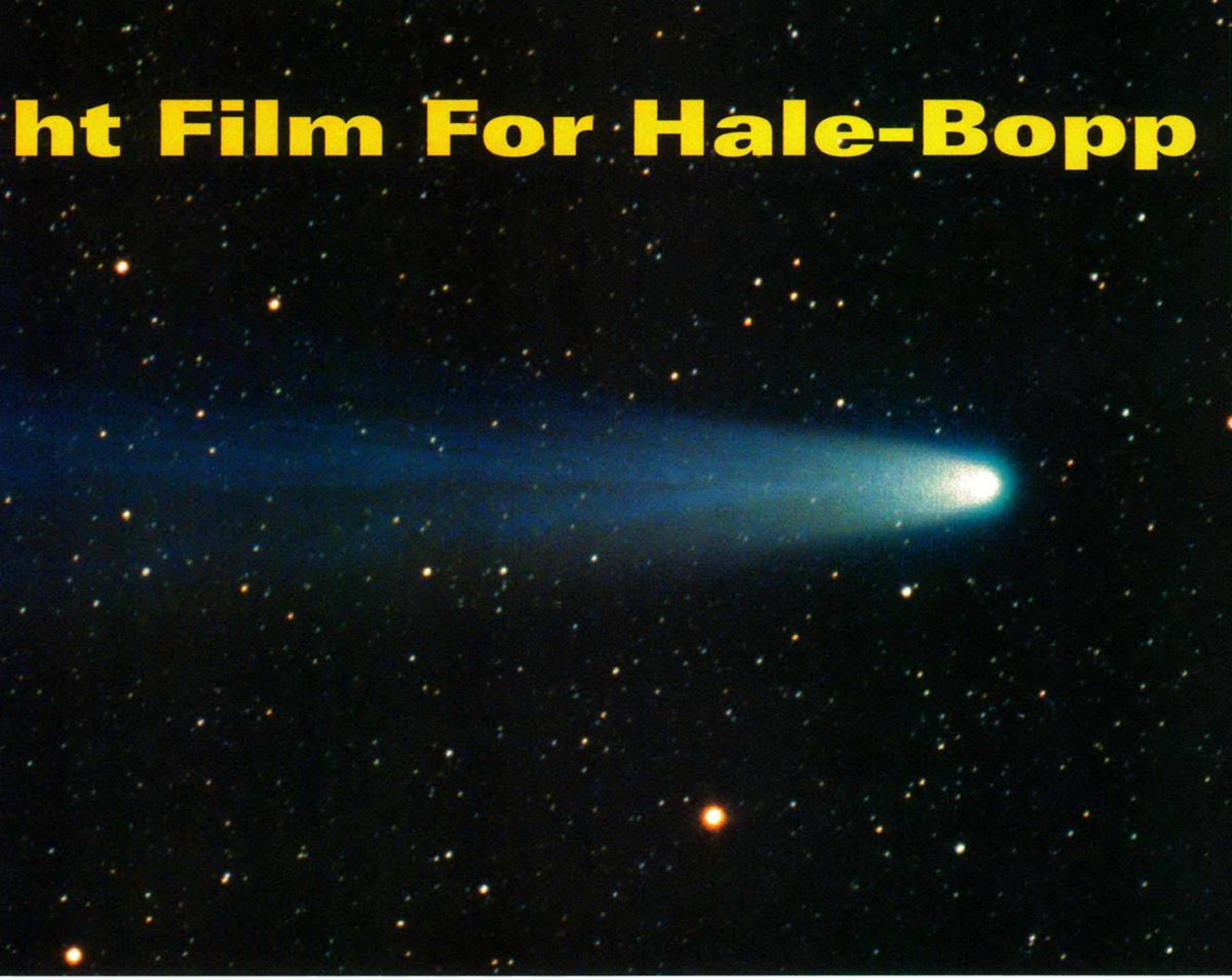
In the past few years, astrophotographers' film choices have improved dramatically. Modern technology has produced faster and finer grained films, with excellent color balance for longer exposures. Never before has it been easier for budding skyshooters to record comets with such clarity and ease. A number of new films from Fuji and Kodak can make comet photography routine and highly successful.

Choose Your Weapons

A good comet film needs several qualities. First, it must respond well in the blue and yellow parts of the spectrum. A comet's long and typically thin gas tail has a subtle sky-blue color, and it usually contains most of the detail. The more spectacular dust tail, which is the last feature to develop as a comet nears the Sun, displays a creamy, pastel yellow color.

Second, a film's contrast is important. If the comet boasts a long, low-surface-brightness tail such as Comet Hyakutake's, choose a high contrast film to bring out faint details. If you want to record fine details such as jets in the comet's head, don't use a high contrast film because the core will burn out, hiding the inner details. A medium- to low-contrast film is best, and will show the full extent of the coma.

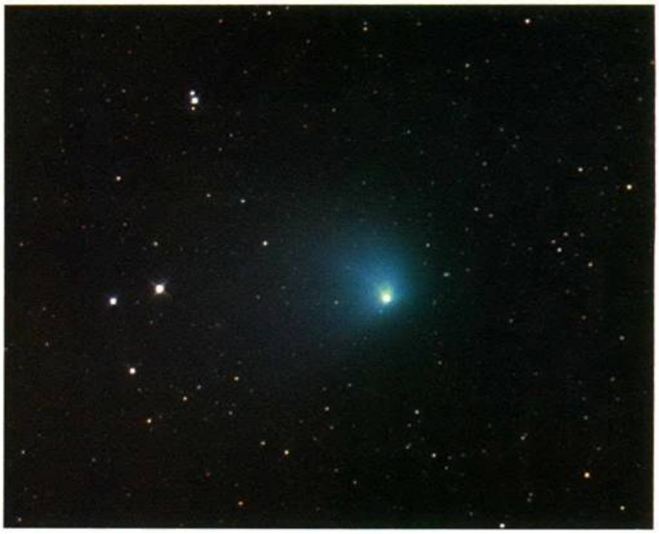
ht Film For Hale-Bopp



Third, a fine grain film is a must for shooting comets. Coarse-grained films work well for stars and wide-angle Milky Way images, where the grains simply look like stars. But comets have delicate gradations from brilliant to dark that will show grain as a sandy texture.

Finally, film speed is important. Because slow films require long exposures, a fast-moving comet will produce a blurred image. You may have to guide on the comet's fuzzy inner coma, a rather difficult task for beginners. You must compromise between grain and speed, and the result must suit the type of lens being used. For most wide-angle and telephoto shots, which are what most backyard skyshooters will be doing, a moderate-speed, fine-grain film is preferred over a fast, grainy emulsion.

Three choices face comet photographers. One must decide between black-and-white negatives, color slides, and color prints. Many skyshooters prefer slides because they can be projected in front of large groups. Some like the rewards of black-and-white darkroom images. But most people choose color negative film to produce colorful prints in quantity.



TOP: Comet Hyakutake, April 11, 1996
(8-inch f/1.5 Schmidt camera, Fuji Super G 800 film, 4-minute exposure)
ABOVE: Comet Hale-Bopp, September 7, 1996
(12.5-inch f/5 Newtonian, Kodak Pro 400 PPF film, 20-minute exposure)

Suggested Exposure Times (in minutes)

FILM	f/1.5	f/2	f/2.8	f/4	f/5.6	f/10
Hypered Tech Pan 2415	1-4	2-8	4-15	8-30	15-60	60+
Kodak TMAX 400	2-8	4-15	8-30	15-60	30-60	N/R
Kodak Gold 400	2-8	4-15	8-30	15-60	30-60	N/R
Fuji Super G 400	2-8	4-15	8-30	15-60	30-60	N/R
Kodak Elite 400	2-8	4-15	8-30	15-60	30-60	N/R
Kodak Pro 400 PPF	2-8	4-15	8-30	15-60	30-60	N/R
Fuji Super G 800	1-4	2-8	4-15	8-30	15-60	60+
Kodak Gold 1000	1-4	2-8	4-15	8-30	15-60	60+
Kodak P1600	.5-2	1-4	2-8	4-15	8-30	15-60

Note: Except for the Kodak Tech Pan 2415, all films are assumed to be off-the-shelf and unhypered.

Black-and-White Negative Films

For black-and-white negatives, two films stand out in the comet shooting arena: Kodak TMAX 400 and Technical Pan 2415 film — Tech Pan for short. A sensible replacement for the grainy standby of Tri-X, TMAX emulsions have much finer grain than their predecessors as well as the desired blue response needed to record a comet's splendid blue gas tail. A good choice of speed for fine grain results is TMAX 400 film, readily available in most camera and department stores.

You can achieve even better results with hypered Tech Pan film. Hypering a film means treating it with nitrogen and hydrogen gas for several hours to make it more efficient. You can buy hypered film from Lumicon (call 510-447-9570). Tech Pan film has ultra-fine grain, a speed equivalent to most ISO 400 emulsions for astrophotography, and it can be developed for any contrast desired. Though many will choose to develop it in the high-contrast D-19 developer for enhanced shots of the tail, there are other choices of developers.

Comet Bradfield, December 20, 1987
(8-inch f/1.5 Schmidt camera, Hypered Tech Pan 2415 film, 15-minute exposure)

You can take better close-up shots of the nuclear region using a slower developer called Technidol, formulated by Kodak to yield extremely fine grain and uniform contrast. You can buy Technidol in most photo supply stores that carry Tech Pan and darkroom supplies. You must use a slower film speed, but hypering will make shots of a bright coma practical.

Color Slide Film

Color slide film is popular for general sky shooting. It has a few drawbacks, one of which is sky fog. In most areas, the color of the night sky is recorded as green or pink in longer exposures. When Comet West flew by in 1976, the local lighting in most areas was almost totally dominated by mercury vapor lamps. This gave the sky a greenish cast, contributing to the already greenish airglow of the natural dark sky. Nearly all exposures of deep-sky objects on slide films were marred by greenish backgrounds. Because a slide was the final result, you had to live with it.

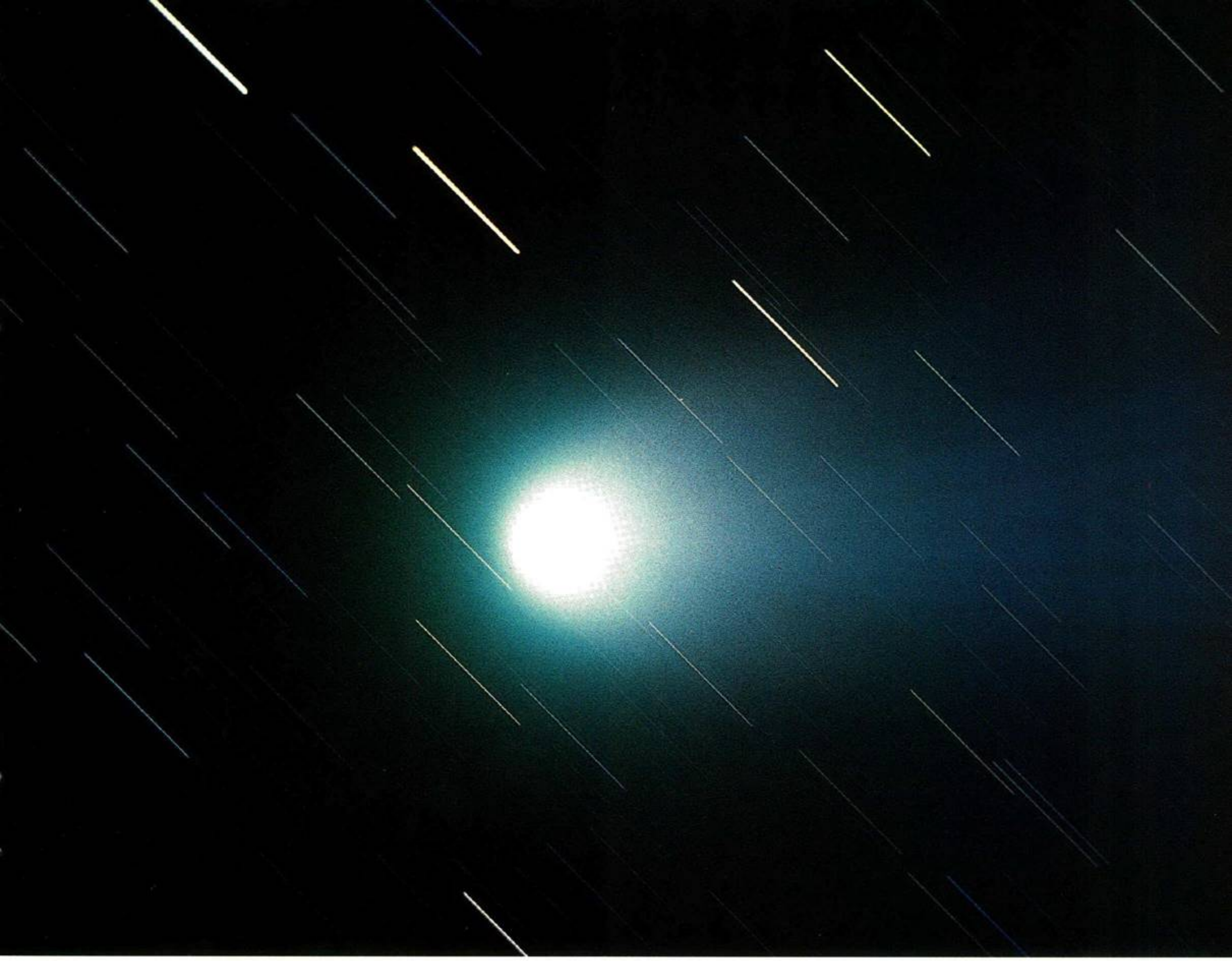
Today, high-pressure sodium lights cause the most intense light pollution. They impart a pinkish cast to the sky — practically opposite the green color of past times. For areas where the sky background is dominated by mercury vapor lamps, or areas far from city lights that have the green airglow, there is an inexpensive way to combat this color cast. Shoot through a weak magenta color-correction filter, available at most photo stores. Correction can vary, but 10 to 30 cc (a common unit of color correction) is typical.

For areas of high-pressure sodium light pollution, a weak green filter can help. Ten to 30 cc of cyan and yellow color correction filters sandwiched together will correct the color to a neutral dark gray. If you use filters of any type, don't forget the rule of thumb that every 30 cc of filtration doubles the exposure time.

Astrophotographers get excellent results with two types of slide films: Kodak Elite 400 and Ektachrome P1600. Both are far less green sensitive than Ektachromes of past years, and they have recorded superb details in the gas and dust tails of recent comets.

Color Print Films

Color negatives offer the widest selection for high-speed films. Three films stand out for fine grain and excellent color response: Fuji Super G 400 Plus and Super G 800 Plus films and Kodak Pro 400 PPF film. The Fuji 800 speed film is fast, has unusually fine grain, and is responsive to both the blue gas and yellow dust tails. The contrast is good, and it meets



nearly all of the requirements for the ideal comet shooting film. Some of the best images of Comet Hyakutake were taken with this film.

Fuji Super G 400 Plus is a finer-grain version of this film. It has excellent blue and yellow response, but it has lower contrast overall than its faster brother. This can be an advantage when used for close-ups of the coma region, where higher contrast films will yield only a featureless, white, burned-out image. This film is ideal for bringing out nuclear jets and the yellow dust around the inner coma. Both films respond well to hypering, yielding a 2- to 3-times increase in speed, and both films can be easily printed to the correct color balance. Select a favorite photo from ASTRONOMY, and provide it to the photofinisher for reference.

Kodak's new professional film, Pro 400 PPF, is rapidly becoming a top choice for comet shooting. The film's superb red and blue response, fine grain, and high contrast make it a good choice for wide-angle lenses to record both the dust and gas tails in excellent detail. When hypered, its speed doubles, and the blue response increases dramatically. The film then becomes ideal for prime focus astrophotography, with a speed and contrast superior to the Fuji Super G 400 Plus.

Comet Hyakutake, March 24, 1996
(6-inch f/3.6 Schmidt Newtonian, Kodak Elite 400 film, 20-minute exposure)

Films to Avoid

Not all films are suitable. When Kodak's Royal Gold series came out recently, many skyshooters rushed out to try them. But nearly all users reported a deep brown background that is difficult for photofinishers to remove without causing improper colors. To avoid this heartache, use Kodak's Gold series of films, which costs less and gives a reasonable color balance. I obtained excellent results on Comets Hyakutake and Kopff with Kodak Gold 400 and 1000. These two films are a distant second choice to the harder-to-find Fuji Super G films, but they can be quite serviceable.

The stage is set, and Hale-Bopp will be acting its part. With some preliminary planning and the correct choice of camera and film, you can capture this historic event to be remembered vividly for years to come. ☐

Chris Schur (cschur@goodnet.com) photographs comets in Arizona with his 12.5-inch Newtonian.

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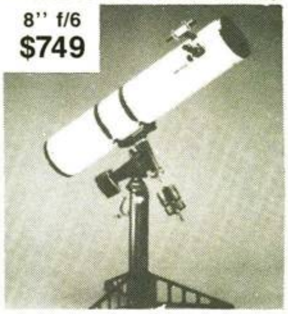
PHOTOGRAPHY ACCESSORIES

Cassegrain EASY-GUIDER 4", 8", f/6 or f/10	**$249**
Giant EASY-GUIDER for 10"/12" f/4-f/10	**$395**

MEADE STARFINDERS

8" f/6
$749



New 8" f/6 Meade Starfinder telescopes

See the Meade ad in this magazine for full descriptions. These are complete telescope systems with motor drive & finderscope (equat. only), mount, and 25mm (=48X) eyepiece. New DC motor runs on 4AA batteries.

6" f/8 Dobsonian Starfinder ($46 P&S)	**$319**
6" f/8 Equat. Starfinder 6(add $79 P&S)	**$649**
8" f/6 Dobsonian Starfinder (add $59 P&S)	**$419**
8" f/6 Equat. Starfinder 8 (add $89 P&S)	**$749**
10" f/4.5 Dobsonian Starfinder ($85 P&S)	**$599**
10" f/4.5 Equat. Starfinder 10 (add $99 P&S)	**$879**
12.5" f/4.8 Dobsonian Starfinder ($95 P&S)	**$895**
16" f/4.5 Dobsonian Starfinder (freight COD)	**$1195**
16" f/4.5 Starfinder 16 (ship. freight COD)	**$2695**

*All Starfinder telescopes shipped directly from Meade to the purchaser. Please add the indicated packing & shipping charge to the price. Slightly lower P&S for payment by check. LUMICON showroom prices are $50-$100 higher.

ACCESSORIES

LUMICON carries all Meade accessories.

LUMICON Single axis drive corrector	**$99**
Magellan computer; specify Dob. or Eq. ($15 ship)	**$295**
Meade 47M Dual-axis drive corrector with tangent arm & electric declination	**$475**

SKY VECTOR™ $299!!

Includes Computer, Encoders, Hardware

LOW PRICE—from $299

LUMICON SKY VECTOR FEATURES:

- "GUIDE" mode leads you to object
- Digital right ascension readout to 1 min.
- Digital decl. readout to 10 arc-min.
- 4000 pulse (0.09° accuracy) encoders
- Polar alignment ***not required!***
- Motor drive ***not required!***
- Just sight two stars to align!
- Works **equally well** for alt-azimuth telescopes like Coulter Odyssey and equatorial mounts like C-8, Meade 2080.
- **No need** to enter latitude, longitude, etc.

SKY VECTOR I™ $299

NEW! With over 220 object memory including the 110 Messier and 58 best NGC objects.

SKY VECTOR II™ $349

10,000 Objects! — Also includes Identify (Sky Tour) Function, planets and full visual descriptions.

NGC SKY VECTOR™ $439

12,000 Objects!— PC Serial Port

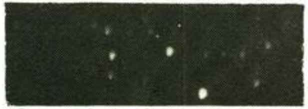
NGC-Sky Vector
OFF ON
DRI
MODE
ENTER
UP
DOWN
LUMICON

NGC SKY VECTOR with IDENTIFY (Sky Tour) mode, 12,000 object memory including the corrected RNGC catalogue, IC catalogue, P&K planetary catalogue, & much more!

Specify Telescope Type: Meade 2045, 2080, 2120, C-8, C-11, Odyssey 8, 10, 13, 17½, Alt-Azimuth, Meade 6-16" Dobsonian.

Ultima 8, 9¼, 11 **add $25**, C-14 **add $75**

COMA CORRECTOR



Coma 1 inch off-axis 17½" f/4.5

Same field with LUMICON coma corrector; smaller, more numerous stars.

This computer-designed LUMICON 2" lens reduces coma and flattens the field for both viewing and photography. **It threads into LUMICON 2" EASY-GUIDERS for effortless installation.** This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Clear aperture = 1.8".

LUMICON 48mm Coma Corrector/Field Flattener Lens	**$285.00**
LUMICON 2" EASY-GUIDER	**$189.50**
2" EASY-GUIDER (Mamiya 645)	**$239.50**
2" Adapter for Pentax 6X7	**$129.00**
2" Adapter for Hasselblad	**$229.00**
2" Adapter for Bronica SQ-A	**$175.00**
2" Extension for viewing	**$26.00**

2" DELUXE BARLOW

1.8x Multiplier Lens (2" Barlow)

LUMICON 1.8x Multiplier Lens (2" Barlow)	**$259.00**

LUMICON ACCESSORIES

LUMICON, Livermore, CA 94550 (510) 447-9570 FAX (510) 447-9589

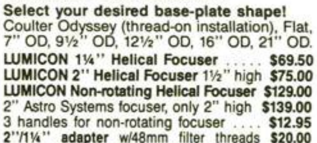
LARGE UV/DUST SEAL

Protect the optics of your 8-14" Schmidt-Cassegrain with a UV/Dust Seal. Simply thread it onto the rear cell, then attach all normal accessories. The large size fits Meade 2120, Celestron-11 and -14 & has a high quality multi coated (removable) 72mm UV filter.

Deep-Sky Filter/Dust Seal for C-8, 2080	**$119.50**
UV/Dust Deal for Celestron C-8	**$39.00**
UV/Dust Seal for Meade 2080, 2045	**$39.00**
UV/Dust Seal (large) for Meade 2120	**$89.50**
UV/Dust Seal for Celestron-11, -14	**$89.50**

LOW PROFILE FOCUSERS
New! Thread-on for Odyssey

FROM $69.50



LUMICON® LOW PROFILE FOCUSERS

LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½" above the telescope tube. Use the 1¼" or 2" versions for viewing. Use the 2" non-rotating focuser for convenient photography with the LUMICON 2" EASY-GUIDER™.

Select your desired base-plate shape!
Coulter Odyssey (thread-on installation), Flat, 7" OD, 9½" OD, 12½" OD, 16" OD, 21" OD.

LUMICON 1¼" Helical Focuser	**$69.50**
LUMICON 2" Helical Focuser 1½" high	**$75.00**
LUMICON Non-rotating Helical Focuser	**$129.00**
2" Astro Systems focuser, only 2" high	**$139.00**
3 handles for non-rotating focuser	**$12.95**
2"/1¼" adapter w/48mm filter threads	**$20.00**
2" LUMICON EASY-GUIDER	**$189.50**

LUMICON 50mm, 80mm SUPER-FINDER™

Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat or 50mm, F=200mm coated achromat. Eyepieces and/or star diagonal are extra.

1¼" 50mm Finderscope **$69.50**, 45°version	**$69.50**
1¼" straight-thru 80mm SUPER-FINDER	**$189.50**
1¼" right-angle 80mm SUPER-FINDER	**$199.50**
1¼" right-angle version, w/star diagonal	**$239.50**
25mm Cross-hair 1¼" eyepiece (12X)	**$59.00**
Large mounting rings for 80mm Finder	**$55.00**
1¼" Star Diagonal **$49**, Mounting Brackets,	**$39.50**
1¼" 45° diagonal for correct left-right views	**$59.50**

LOTS OF ADAPTERS

2" adapter for C-8, Meade 2080, etc.	**$29.50**
2" adapter for C-80, C-100 refractor	**$39.50**
2" adapter for C-70, C-80F, C-100F fluorite	**$39.50**
2" adapter for C-6, Comet Catcher, Meade 312	**$30.00**

EXTENSION TUBES

1" long 1¼" OD thread-in extension	**12.00**
2½" long extension (holds 1¼" filters)	**19.50**
4½" long extension for 1¼" eyepieces	**$29.00**
3" long extension for 2" eyepieces*	**$29.00**
2" long extension for 2" eyepieces*	**$29.00**

VIEWING ADAPTERS

2"/1¼" reducing bushing,threaded 48mm*	**$25.00**
2"/T-thread adapter, threaded 48mm*	**$25.00**
T-thread/1¼" adapter	**$25.00**
F/10 2" or 1¼" eyepiece viewing adapter for Giant Easy-Guider	**$39.50**
Low profile star diagonal eyepiece holder	**$16.00**
Meade 2" Diagonal/Giant Easy-Guider	**$39.50**

**Threaded to hold 48mm filters.*

WRITE NO. 51 ON THE READER SERVICE CARD

Meade & Celestron
LUMICON carries a full line of telescopes and accessories. Fast Delivery. Competitive Prices.

LUMICON FOR HIGH PERFORMANCE

Visit our LUMICON web-site: http://www.rahul.net/Astro-Mall

NEW LUMICON MULTIPLE FILTER SELECTOR

$129

ALWAYS GET THE BEST VIEW!

$99
(If ordered with filter or filter set)

The New LUMICON Multiple Filter Selector holds up to 5 1¼" LUMICON filters. The sliding bar has a click-stop at each filter position. Now you can instantly select the best filter for any deep-sky object. Cost is $129 or $185 with 1.5X relay lens (for Newtonians). **Save $30 if ordered with filter(s)!**

TELE VUE™

NEW! Bino Vue Binocular Viewer

Genesis-SDF 4" f/5.4 apochromat	**$1950**
Pronto 70mm f/6.4 apochromat w/2" diagonal	**$939**
Pronto 70mm f/6.4 w/45° erecting prism	**$789**
NEW! Bino Vue binocular viewer	**$899**
Gibraltar mount with ash wood tripod	**$495**
10.4, 26mm Plossl 50°	**$79**
8, 11, 15mm Plossl . **$89**, 20, 25mm	**$99**
32mm Plossl, widest true field in 1¼"	**$119**
55mm 2" Plossl, widest possible field	**$229**
2.0x or 3.0x Tele Vue Barlow Lens	**$115**
2" Giant Barlow - 2x	**$179**
15mm Wide-Field, 1¼" eyepiece, 65°	**$139**
4.8mm Nagler, 82° field, 1¼" eyepiece	**$169**
7mm Nagler, 1¼" eyepiece, 82° field	**$219**
9mm Nagler, 82° field, 1¼" or 2"	**$239**
13mm Nagler, 82° field, 1¼" or 2"	**$299**
12mm Nagler, Type II, 82°, 1¼"/2"	**$279**
16mm Nagler, Type II, 82°, 1¼"/2"	**$299**
20mm Nagler, Type II, 82°, 2" only	**$375**
2" Paracorr Visual Coma Corrector	**$249**
15mm Panoptic 1¼", 68° field	**$209**
19mm Panoptic 1¼", 68° field	**$245**
22mm Panoptic 1¼"/2", 68°	**$269**
27mm Panoptic 2", 68° field	**$319**
35mm Panoptic 2", 68° field	**$349**

TeleVue Warranty may not be valid outside USA.

NEW! ENHANCED ALUMINUM DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3" & 2.1" enhanced aluminum diagonal mirrors & 1¼" star diagonal.

The new LUMICON diagonal mirrors have a special enhanced aluminum coating with a protective overcoating for long life. Visible reflectivity is 94-96% compared to 86-89% for standard aluminum coated mirrors. The extra 5-10% transmission is like adding up to an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32"	**$39.50**	1.52"	**$45.00**	1.83"	**$49.50**
2.14"	**$59.50**	2.60"	**$75.00**	3.10"	**$99.50**

ENHANCED ALUMINUM STAR DIAGONAL

90° star diagonals with 96% reflectivity enhanced aluminum mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

1¼" (1.32" mirror)	**$99.50**
2" (1.83" mirror)(see photo above)	**$189.50**

LUMICON FILTERS — BEST IN THE WORLD!

"The LUMICON O-III proved to be our favorite... It gave the greatest contrast gain." ***ASTRONOMY*, February 1991**

AMAZING O-III FILTER™

Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

GREATLY ENHANCED DETAIL

"Consistently performed well on all emission and planetary nebulae. Detail and structure were greatly enhanced in the more than two dozen objects I viewed." ***SKY & TELESCOPE*, July 1995**

BETTER THAN A DARK-SKY SITE!?

"From my light polluted backyard, the view ... was better with the O-III than with any other filter tested. The view was even better than without the filter from a dark-sky site." ***SKY & TELESCOPE*, July 1995**

SEE THE HORSEHEAD!

*"**LUMICON's H-Beta Filter** will show subtle features in emission nebulae that the others fail to reveal. It can't be beat for the elusive Horsehead and California nebulae. . ."* ***SKY & TELESCOPE*, July 1995**

"I CAN SEE THE VEIL NEBULA!"

Rich Zepernick saw the Veil Nebula for the very first time with a **LUMICON UHC Filter**. He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters."*
Rich Zepernick, Cresskill, NJ

DEEP-SKY FILTER™

BEST for Astrophotography!

"Stunning is all I can say," says noted astrophotographer Jack Newton. Great for BOTH color and black and white photography.

BEST WIDE-BAND FILTER!

*"Based on our tests we'd recommend a LUMICON Deep-Sky and Oxygen-III as complementary filters. The LUMICON Deep-Sky Filter clearly had the best contrast for **reflection** nebulae."* ***ASTRONOMY*, February 1991**

	Premium*
0.96" LUMICON DEEP-SKY Filter threads into most 0.96" eyepieces	$59.50
1¼" LUMICON DEEP-SKY Filter threads into most 1¼" eyepieces	$99.50
48mm LUMICON DEEP-SKY Filter (1.7" aperture), threads into most 2" eyepieces. Also fits LUMICON EASY-GUIDERS	$199.50
2" LUMICON DEEP-SKY Filter (1.5" aperture), threads into most 2" eyepieces. Also has male & female camera T-threads for prime focus photography	$199.50
72mm LUMICON Giant DEEP-SKY Filter (62, 67, 77mm adapter, $10, 82mm $16)	$399.50
2" Rear Cell Filter, fits SCT's . . . Deep-Sky, **$199.50** UHC, O-III, H-Beta,	$199.50
1¼" LUMICON UHC Filter threads into most 1¼" eyepieces	$99.50
48mm LUMICON UHC Filter (1.75" aperture) fits most 2" eyepieces	$199.50
Choice of ***any two*** LUMICON filters (**Save 7%**) . . . 1¼" **$185.00**; 48mm	$370.00
LUMICON H-BETA Line Filter (9mm bandpass at 486nm). For the California Nebula, Horsehead Nebula, and other extremely faint nebulae. **1¼"** . . . **$99.50, 48mm**	$199.50
Oxygen-III Filter for very faint planetary and diffuse nebulae, 11nm bandpass at 496nm and 501nm O-III lines . . . 1¼" **$99.50; 48mm**	$199.50
LUMICON Comet (Swan band) Filter . . . 1¼" **$99.50; 48mm**	$199.50
Telephoto lens adapter for 2" or 48mm filter. Select 46, 49, 52, 55, 58mm	$7.95
Universal adapter for 1¼" filters. Adapts the 1¼" filters to any 1¼" eyepiece	$19.50
Universal adapter for 48mm or 2" filters. Allows use of any 1¼" eyepiece	$25.00

**Premium filters are currently the best in the world. All Lumicon filters include individually measured transmission data.*

ADJUSTABLE PIGGYBACK MOUNT

The LUMICON adjustable piggyback mount is ideal for telescopes of 6-16" aperture. It permits **both** vertical and sideways adjustment for optical alignment. Also ideal to mount LUMICON 80mm SUPER-FINDER™, large telephoto lenses and small telescopes up to about 5 lbs.
LUMICON Adjust. Piggyback Mount $59.50
Specify telescope size: 6", 8", 10", 11", 14", 16"

H-ALPHA PASS FILTER

Yields spectacular contrast gains in B&W photograph with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the LUMICON Deep-Sky (DS) Filter.

Specify Lens Size	**H-Alpha**	**(DS)**
46, 48, 49mm	**$59.00**	**$199.50**
52, 55, 58, 62mm	**$69.00**	**$199.50**
67, 72, 77mm	**$79.00**	**$399.50**
82mm (77mm + adapter)	**$89.00**	**$415.00**

Hypered 2415 film, 36 exp . . **$11.95, $3/$32**

LUMICON®
2111 Research Dr. #5A, Livermore, CA 94550
For phone orders please call (510) 447-9570
FAX (6 PM-9 AM PST) (510) 447-9589
LUMICON Products catalogue FREE
All foreign orders add 8% ($10 minimum)
California residents add 8.25% tax.
Prices subject to change w/o notice.
Hrs: M-F 9 am - 5 pm, Sat. 9 am - 1 pm

DEEP-SKY ASTROPHOTOGRAPHY

SR-V 3200 NEW FILM

FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15x film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

†U.S. Patent 4,473,636

MAKE YOUR OWN HYPERED FILM

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$325**

MODEL 600 HYPER-KIT (See photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$395**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller . . . **$595**

Temperature controller for any HYPER-KIT **$75**

Electric Vacuum Pump, Model R-10 **$325**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms for bright guide-stars. †U.S. Patent 4,448,500
Specify Camera and Telescope type.

NEWTONIAN EASY-GUIDER™

Full aperture. Installs in seconds. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER	**$189.50**
48mm Coma corrector/field flattener	**$285**
3X Relay Diagonal (see photo)	**$99.50**
Illuminated reticle eyepiece, pulsed	**$109.50**

Guider for Hasselblad **$409,** Mamiya 645 **$199**
Pentax 6X7 **add $119;** Pentax 645 **add $139**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Cynamax-8. Includes 50mm achromatic lens for f/5.8 operation—3X shorter exposures! **Superb rich field viewing, too!**

CASSEGRAIN EASY-GUIDER **$249.00**
Adapter for Hasselblad **$225,** Mamiya 645 **$98**
Pentax 6X7 **add $119;** Pentax 645 **add $139**

GIANT EASY-GUIDER™

For Celestron-11, C-14, and the 10-12" Meade. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

GIANT EASY-GUIDER **$395.00**
48mm DEEP-SKY Filter ordered with any EASY-GUIDER (SAVE $20) . . . . . **add $99.95**
Adapter for Hasselblad **$295,** Mamiya 645**$149**
Pentax 6X7 **add $129;** Pentax 645 **add $149**

WHAT DO YOU NEED?

1. **Illuminated reticle eyepiece** . . . $109.50
Lumicon 12mm eyepiece system has adjustable LED illumination, dual crosslines, pulsed.

2. **Cable release** for long exposures . **$9.95**

3. **Declination motor** (state telescope type) **$109**

4. **Dual-axis drive corrector** for telescope. This should be part of the telescope when purchased. Call LUMICON for details.

5. **LUMICON EASY-GUIDER** (selection to left)

6. **LUMICON 48mm DEEP-SKY FILTER $199.50**
This is essential for highest possible contrast. Contrast is boosted up to 3X for ***both*** color or black & white photos. The 3 photos in this ad showing the Helix Nebula, Horsehead Nebula and Veil Nebula were all made using a LUMICON 48mm DEEP-SKY FILTER.

7. **Hypersensitized film.** Purchase from LUMICON or make your own with a LUMICON HYPER-KIT.

TRY PPF! HYPERSENSITIZED FILM

SR1600
Scotch
1000

HYPERED FILM IS 2-10X FASTER!

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.). ***No C.O.D.s.***

Film Type, 35mm	**Exposures**	**Price**
Kodak PPF-400, THE BEST!	36	**$14.95**
2415, Ultra-fine B&W, red sens.	36	**$11.95**
SR-G3200, fastest of all, color neg	24	**$13.95**
Kodak Gold 1000 fast, fine grain	12	**$13.95**
Fuji G800 fine grain color neg.	**24**	**$13.95**
Ektachrome 1600, fast slide film	24	**$14.95**
Fujichrome RD100, fine grain slide	24	**$12.95**
D-19 B&W Developer	1 gal.	**$6.95**

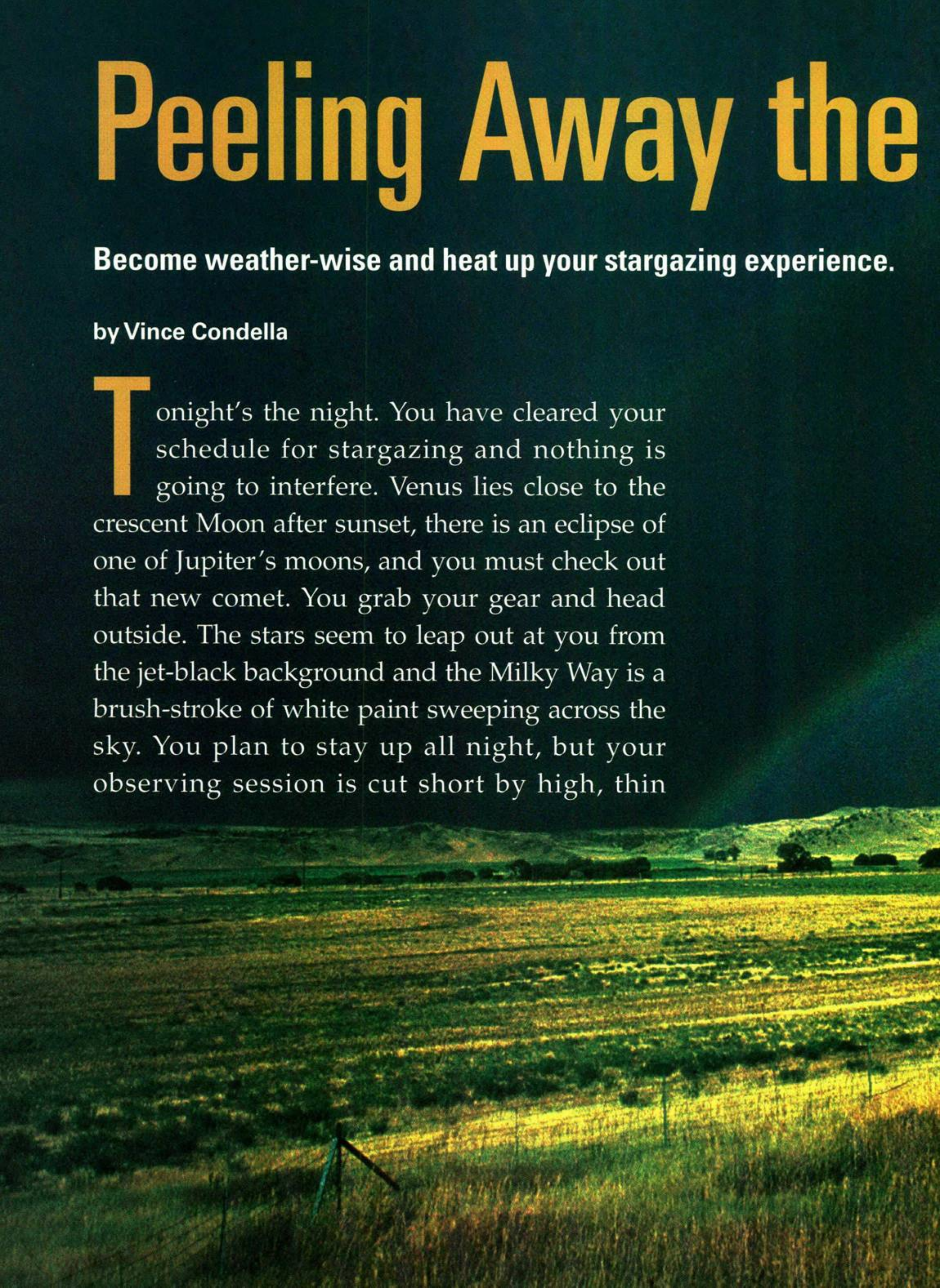
WRITE NO. 51 ON THE READER SERVICE CARD

Peeling Away the

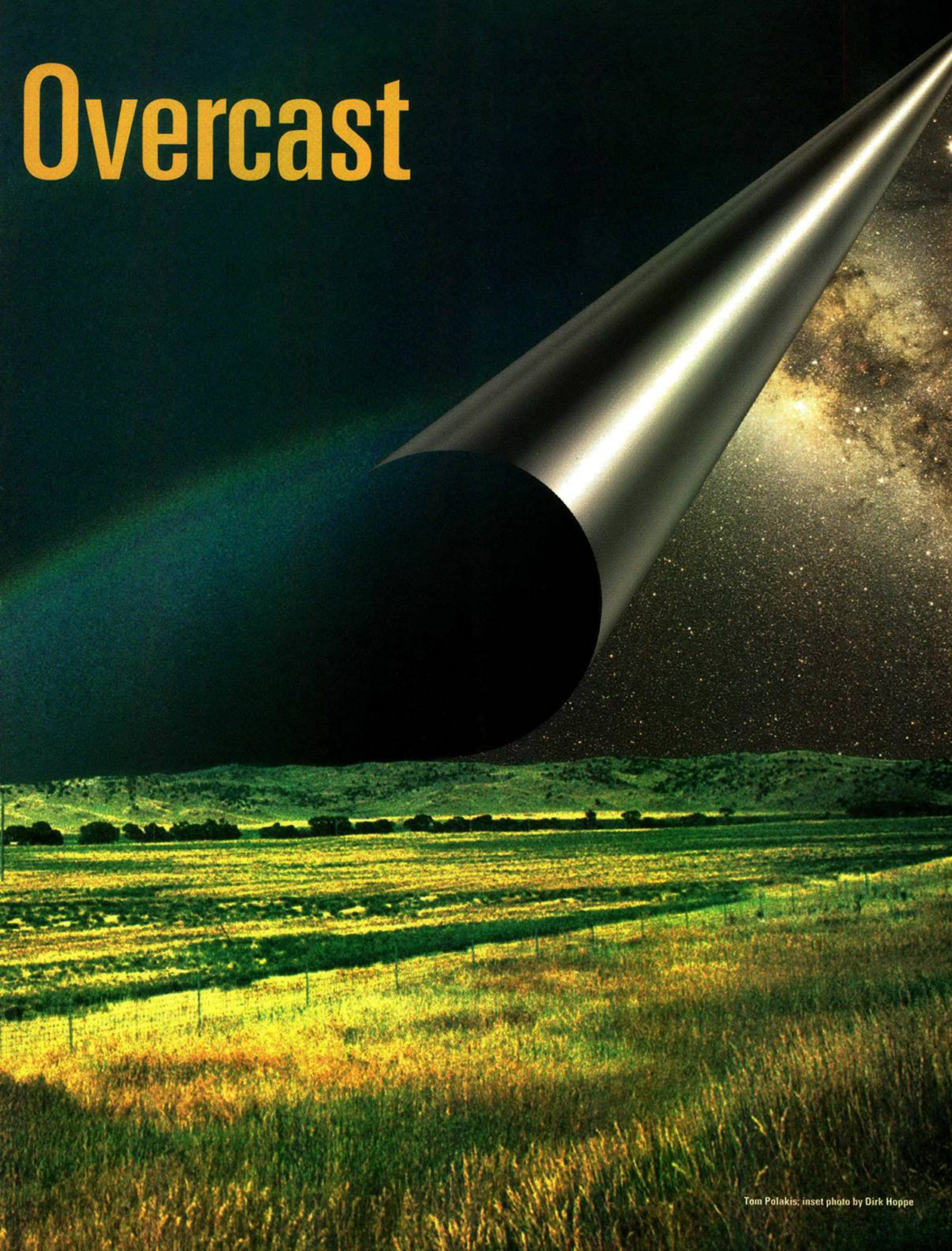
Become weather-wise and heat up your stargazing experience.

by Vince Condella

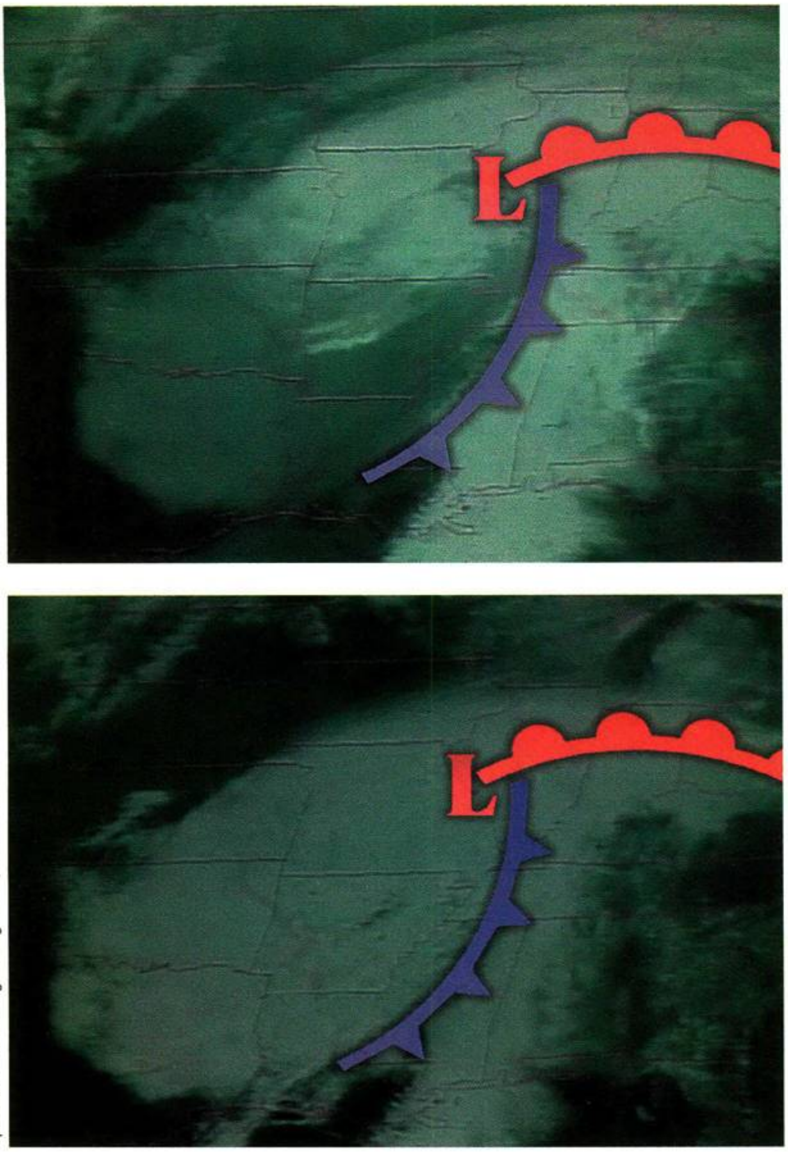
Tonight's the night. You have cleared your schedule for stargazing and nothing is going to interfere. Venus lies close to the crescent Moon after sunset, there is an eclipse of one of Jupiter's moons, and you must check out that new comet. You grab your gear and head outside. The stars seem to leap out at you from the jet-black background and the Milky Way is a brush-stroke of white paint sweeping across the sky. You plan to stay up all night, but your observing session is cut short by high, thin



Overcast



Tom Polakis; inset photo by Dirk Hoppe



Sensors on board geostationary meteorological satellites image Earth in several wavelengths, but the infrared (upper) is the most important when predicting a good night for stargazing. Visible imagery (lower) doesn't show high, thin cirrus clouds very well. These clouds won't reflect much visible sunlight but can ruin an otherwise good night of observing.

Space Science and Engineering Center, UW-Madison

clouds that suddenly thicken to a solid overcast. Had you paid closer attention to the daytime sky and watched the evening weather forecast, you could have saved yourself a lot of time and disappointment.

It's possible to look for items in the daily weather report that can clue you in to the type of viewing conditions you will have later in the night. Knowing both the air and dew point temperatures tell you a lot about water vapor near your observing site. The distance between you and high or low pressure centers and frontal boundaries determines your odds of a cloud-free night. Even the exhaust from high-altitude jet aircraft crisscrossing the daytime sky can be a road map for nighttime weather conditions. Whether your source of local weather information is the newspaper weather page, the local television weather report, The Weather Channel, or an Internet weather page on the World Wide Web, certain atmospheric situations lead to better observing conditions.

Water Vapor

The rule is simple: Less water vapor means better observing. Water droplets play havoc with incoming light, distorting and diffusing an object's good looks. Earth's atmosphere contains 0 to 4% water vapor by volume, a range that includes the deserts and polar regions on one end and the tropics on the other end. Water vapor concentrates near Earth's surface because the weight of the atmosphere, also known as barometric pressure, is greatest at sea level.

Gravity keeps most of the atmosphere's molecules near the ground and those include water vapor. Since gravity also keeps you on the ground, decreasing the amount of water vapor between you and the night sky is a constant challenge. You can't fight gravity but you can dodge the water vapor bullet by observing in a desert location or on a mountaintop.

However, if mountains or deserts are not part of your observing itinerary, then colder nights are better than warmer nights. Dressing in layers or putting on a heavy parka may not be as convenient as wearing shorts and a t-shirt, but for crystal clear skies, nothing beats the cold. Observing on a winter night can be a breathtaking experience, and not just because of the icy cold temperatures. The best viewing conditions usually go hand-in-hand with the coldest of nights because the atmosphere's capacity to hold water vapor decreases as the thermometer drops.

Relative Humidity

A word of warning here: Pay no attention to relative humidity. It will only confuse you and lead you astray. Relative humidity is the ratio of the amount of water vapor actually in the air to the amount of water vapor the air can hold at that particular temperature and pressure. Air with 100% relative humidity is saturated because it is filled to capacity with water vapor. Air with 50% relative humidity contains one-half the amount of water vapor it could hold.

But the amount of water vapor is relative to the air temperature. If your observing location has an air temperature of 60° F and a relative humidity of 30%, the air will contain more water vapor than a location with an air temperature of 20° F and a relative humidity of 100%. Yes, the colder location has saturated air at Earth's surface, but there will be less water vapor to interfere with celestial viewing at the colder location than at the warmer location. The atmosphere at 60° F

Condella's World Wide Web Weather Winners

There are countless sources of weather information on the Internet. Here are my favorite four. I recommend Netscape or a similar graphics-friendly browser and a fast modem — 28.8 BPS speed is preferred with 14.4 BPS a minimum requirement.

Weathernet

This is the hands-down winner of weather websites. Sponsored by the Weather Underground at the University of Michigan, everything is here including an extensive list of hundreds of other weather websites. The Weather Cams are the best part. You can call up current images of weather from around the United States, including Hawaii. How about a view of sky conditions from the Vail ski slopes? — ***http://cirrus.sprl.umich.edu/ wxnet/***

Interactive Weather Information

This site is from the National Weather Service. It contains worldwide weather information but focuses mainly on the United States. It provides excellent Doppler radar images from cities coast-to-coast as well as regional composite radar images covering several states. High resolution visible and infrared satellite imagery is also available. — ***http://iwin.nws.noaa.gov***

WXP The Weather Processor

Purdue University sponsors this outstanding website. You'll have access to everything from surface weather analysis to satellite and radar images. It also provides graphic displays of various numerical prediction computer models of the atmosphere that meteorologists use to forecast weather. —***http://wxp.atms.purdue.edu/***

The Daily Planet

The best thing about this website from the University of Illinois is the Weather Visualizer. You can customize the data you receive, displaying only the parameters you request. You can see the latest surface weather observations superimposed on the latest satellite image by simply indicating your choice.— ***http://www.atmos.uiuc.edu/***

has the capacity to hold four times as much water vapor as the atmosphere at 20° F.

The Dew Point

Now that you are determined to ignore relative humidity, turn your attention to the dew point temperature during the hours prior to observing. The air temperature must cool to the dew point temperature in order for water vapor in the atmosphere to condense into liquid water, such as fog, haze, or dew on the grass. When the air temperature matches the dew point temperature, the air is saturated and filled to capacity with water vapor.

Conditions with large temperature to dew point spreads are more favorable for atmospheric seeing. As this spread decreases, moisture in the air becomes more visible. Let's say it is 2 p.m. on the day of your big observing night. The air temperature is 75° F and the dew point temperature is 50° F. Once the Sun sets, the air temperature will drop quickly, especially if winds are light and the sky is mostly cloud-free. Under these conditions, daytime surface heat escapes rapidly from Earth's surface.

The dew point should remain nearly constant during the night as long as there is no additional moisture advancing into your area with an approaching weather system. At 9 p.m. the air temperature has cooled to 60° F and the dew point remains at 50° F, but the cooler nighttime air doesn't have the same capacity to hold water as the warmer daytime air. As the temperature-dew point spread decreases, expect atmospheric seeing to deteriorate. As a general rule, a temperature-dew point spread of less than 5° F will result in the formation of haze or fog in the lowest 500 feet of the atmosphere. Colder air will correct that problem. For example, a night with a temperature of 20° F and a dew point of 17° F will offer better seeing than a night with a temperature of 50° F and a dew point of 47° F. The spread is only 3° F both nights, but the atmosphere at 20° F holds less water vapor than the 50° F air. There is less water vapor condensing on a cold night and therefore less water vapor to get between you and the night sky.

Observing on a winter night can be a breathtaking experience.

The Weather Map

Daily weather maps are usually dotted with blue lines with triangles (cold fronts), red lines with bumps (warm fronts), alternating red and blue lines with triangles and bumps (stationary fronts), and the letters H and L (high and low pressure).

If your observing site is near a frontal boundary, you are in store for a less-than-adequate night of viewing the sky. Fronts are collision zones between different types of air masses. As they converge, the water vapor in these air masses is lifted, cooled, and condensed into liquid water either in the form of clouds or haze. Even a weak stationary front with little differ-

Ralph Wetmore/Tony Stone Images

Is your observing obsession constantly overshadowed by weather? You can be more prepared if you know what to look for.

ence in air mass on either side of it can create haze in the lower 1,000 feet of the atmosphere.

Fronts are usually attached to low pressure centers (the red letter L on weather maps). Surface winds spiral in toward the center of a low, converge, and then lift. Often the thickest cloud cover is within 100 miles of the low pressure center.

The odds of better atmospheric transparency increase closer to a high pressure center (the blue letter H). Air near the high is sinking, hitting the ground, and spiraling out away from the center. The sinking motion inhibits cloud formation by preventing water vapor from rising, cooling, and condensing. But not all highs on a weather map are created equal. The slow sinking motion may trap moisture near Earth's surface, forming fog or low-level haze when air cools after sunset. The best bet for clear viewing near a high pressure center is with a cold, polar air mass. This cold pool of air contains very little water vapor anyway, so the small amount that gets trapped beneath sinking air may not form fog or haze.

Watch the movement of fronts and pressure systems to get an accurate picture of how weather at your observing site will change. Don't be discouraged if you observe a south wind, clouds, and rain on the morning of your astronomy night. Check the latest weather maps to see if a front is moving through your area. The passage of a cold front later in the day will shift winds to the west or northwest, push the clouds and rain off to the east, and lower the dew point and water vapor content of the air. While cold fronts may become your best friend and welcomed with open arms, you will learn to loathe the warm front. The slope of the warm front is gradual, as warm air slides up slowly above the cooler air below. This slow rise means that as the air cools and condenses, the resulting water vapor spreads itself out like a blanket to form stratiform clouds that can reach over one hundred miles north of the warm front.

In contrast to this is the sharp slope of the cold front. Cold air is denser, or heavier, than warm air, so the cold air easily displaces the warm air, pushing it upward rapidly like a snowplow. Clouds along a cold front are cumuliform, meaning they are piled high and can create thunderstorms or brief rain showers. These clouds can extend vertically to more than 50,000 feet, but when clumped together along a cold front, are rarely more than 50 miles wide. And because of the greater density of cold air, cold fronts move faster than warm fronts. The cold front and its associated clouds can be in and out of your area in less than 12 hours. Warm fronts can linger for days.

Satellite Images

Nothing shows the rapid clearing behind a passing cold front better than the view from outer space. But there is a lot more than meets the eye when viewing weather satellite photos. They can show you the twist and curl of that big storm approaching and they illustrate the fluid nature of the atmosphere. You can literally trace out the flow of winds in the middle and upper layers of the troposphere (lowest layer of the atmosphere extending from the surface to approximately 40,000 feet) by viewing the satellite loops presented on television weather reports. These loops display the past several hours of satellite imagery in consecutive order, with each image produced every 15 to 30 minutes. A 24-hour satellite loop may consist of nearly 100 images from space.

The geostationary meteorological satellites orbit Earth over the equator at an altitude of approximately 23,000 miles. Since their orbital speed matches Earth's rotational speed, the satellites remain parked over one spot and provide continuous coverage of cloud systems over the same part of the world. Sensors on board the satellites image Earth in several wavelengths, but the infrared image is the most important when predicting a good night of sky observing.

Television weather reports show either visible or infrared satellite images. As the name implies, the visible image simply records sunlight bouncing off clouds. It's great for showing dramatic thunderstorms mushrooming during the late afternoon, but useless at night. Visible imagery also does not show high, thin, cirrus clouds very well. These ice crystal clouds occur above 25,000 feet. They usually don't reflect much visible sunlight but can totally ruin a night of observing by making the sky opaque.

Always check the infrared satellite imagery. Visible imagery shows shadows cast from higher clouds onto lower clouds. Infrared satellite images usually have a much greater range of gray-to-white shading of the clouds. The gray scale is important to note because infrared images are sensing the temperatures of the cloudtops. Brighter cloudtops indicate colder clouds found high in the troposphere. Darker gray clouds are warmer and therefore closer to Earth's surface. A high, thin, cirrus cloud can go almost undetected on a visible image but shows up as a bright streak of white on an infrared image.

Jet Contrails

Jet contrails are good indicators of moisture. They are created by the exhaust from jet aircraft traveling across your area at cruising altitude. Look for these in the daytime sky when predicting weather conditions for later that night. It is common for the air temperature above 30,000 feet to be –60° F or colder. Jet engines operating at that altitude are producing exhaust much warmer than the surrounding air. The moisture in the exhaust cools rapidly and condenses, resulting in a thin, white ice crystal cloud called a jet contrail. The jet contrail will be short if the air at cruising altitude is dry. A long contrail is a result of a moist layer of air at high levels. It may indicate an approaching weather system and the appearance of cirrus clouds during the next 12 hours.

Since observing the heavens from the space shuttle or the Hubble Space Telescope is out of reach for most amateur astronomers, Earth's atmosphere will always get between you and the objects you view. Preparing for a night of observing means more than just transporting your equipment to your favorite dark-sky location. Making the extra effort to examine atmospheric conditions before you venture outside can prevent frustration and unwanted surprises. A check of the daily weather map or a peek at the latest satellite image offers important clues to what lies ahead in the night sky. Ben Franklin wrote, "Some people are weatherwise, but most are otherwise."

Making the extra effort to examine atmospheric conditions before you venture outside can prevent frustration.

For the amateur astronomer it helps to be a member of the first group. □

Vince Condella is the chief meteorologist for WITI-TV, the Fox affiliate in Milwaukee, Wisconsin. He enjoys explaining the wonders of the atmosphere to his viewers.

Vince Condella

Jet contrails from aircraft indicate moisture levels in the air. The shorter the contrail, the less moisture.

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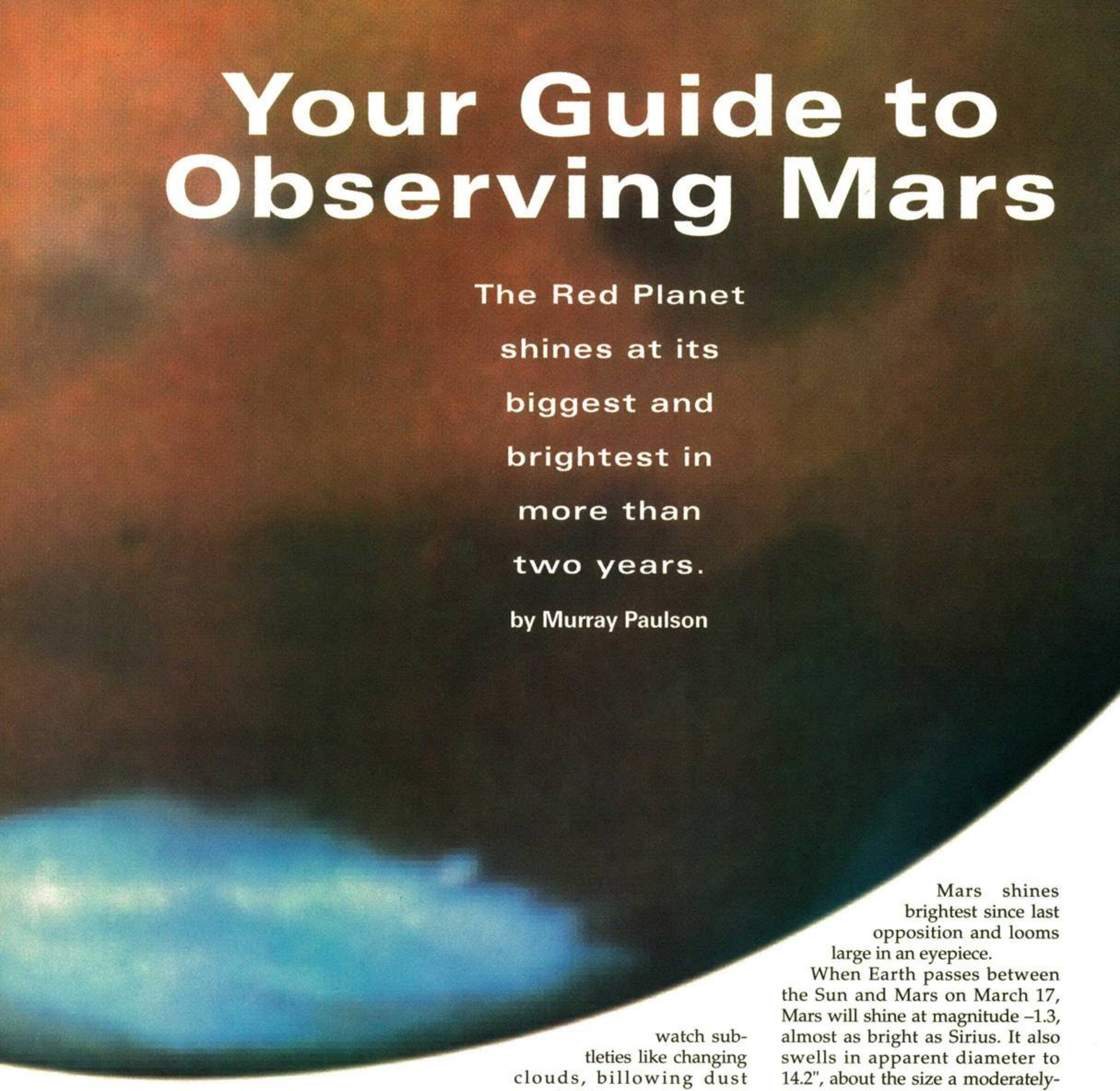


Your Guide to Observing Mars

The Red Planet shines at its biggest and brightest in more than two years.

by Murray Paulson

Mars is a planet of intrigue and wonder. It is the planet in our solar system most like Earth, complete with an atmosphere, polar caps, deserts, clouds, and seasons. And now there are tantalizing hints of life in a martian meteorite.

Against this backdrop, Mars shines like a gem in the March night sky, beckoning you to make a few discoveries. Arm yourself with a 4-inch or larger telescope to watch subtleties like changing clouds, billowing dust storms, a shrinking polar cap, and shifting sands.

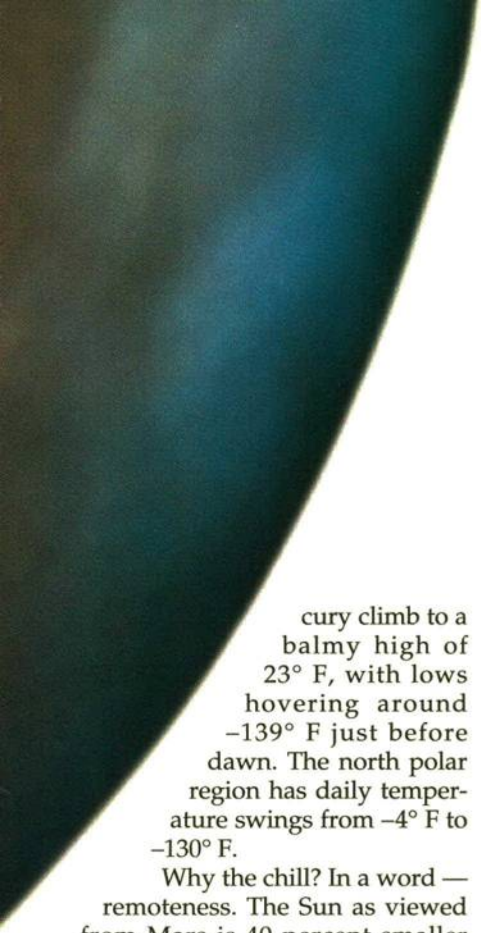
Something Red This Way Comes . . .

Mars shines at its brightest in the night sky every two years and two months. This is how often it undergoes opposition, a time when Earth stands directly between Mars and the Sun. At opposition, Mars rises in the east at sunset, lies due south at midnight, and sets in the west as the Sun rises. It is also the time when Mars shines brightest since last opposition and looms large in an eyepiece.

When Earth passes between the Sun and Mars on March 17, Mars will shine at magnitude –1.3, almost as bright as Sirius. It also swells in apparent diameter to 14.2", about the size a moderately-sized crater looks on the Moon when viewed through a telescope.

Over the coming two months, this enlarged disk shows subtle changes as spring changes to summer in Mars' northern hemisphere. The polar cap will dwindle to insignificance, and features in the northern latitudes alternately get obscured and unveiled by dust storms and clouds.

Summer on Mars is a far cry from the summers we're used to on Earth. A typical summer day in the martian tropics sees the mer-



cury climb to a balmy high of 23° F, with lows hovering around –139° F just before dawn. The north polar region has daily temperature swings from –4° F to –130° F.

Why the chill? In a word — remoteness. The Sun as viewed from Mars is 40 percent smaller than we see it from Earth, and conveys only a third as much energy as we enjoy on our planet. However feeble this amount of energy may be, it is still enough to drive the weather in Mars' thin carbon dioxide atmosphere. This leads to dust storms, high clouds, and ice fogs that periodically alter or hide features on the martian surface.

Except for polar caps and a few major dark markings, Mars' features are low-contrast. But just as fishermen wear Polaroid sunglasses to scan a river bottom through glare for fish, we can apply different colored filters to enhance certain features on Mars.

A comprehensive set includes a red Wratten #25 or #23, an orange Wratten #21, a yellow Wratten #12 or #15, a green Wratten #11 or #58, a blue Wratten #80A, and a violet Wratten #47. These filters screw into an eyepiece, and are readily available from a variety of accessory manufacturers.

Red filters (and to some extent, orange) work well due to the fact that most of Mars is covered with iron oxide minerals: rust. Darker areas, called maria, overlie the general redness of Mars. They are regions mainly composed of a mix of volcanic material and other darker minerals. Observers typically use red filters to enhance the contrast of these maria, and to monitor their shape and definition as winds shift dust around the martian globe. Areas to keep a watch over are Solis Lacus, Chryse-Acidalium, Isidis, and Syrtis Major.

If you have a fairly large scope, a Wratten #25, a dark red filter, should both reduce the planet's glare and enhance the maria contrast. If your scope's aperture is 8 inches or smaller, use a light red Wratten #23 or an orange Wratten #21 filter. To nab periodic dust clouds and dust storms, use a yellow filter to enhance contrast. Of the popular yellow filters, Wratten #12 has a lighter color, while #15 saturates more color for greater contrast.

You can also get an idea about how much dust is suspended in Mars' atmosphere by observing with a green filter. Green filters also reveal low-lying, springtime clouds along India-shaped Syrtis Major. As an added bonus, green will also betray any ground frost in the large, low-lying basins of Argyre and Hellas.

Besides monitoring the atmosphere for dust, be on the lookout for clouds and hazes that show up bright when viewed through blue and violet filters. These filters tend to expose high-altitude clouds, while the green shows lower-altitude hazes. If you spot a bright haze through a green filter and find that it disappears or gets smaller in blue or violet, then the cloud is close to the ground.

Blue and violet filters also show certain kinds of ice fog that appear as bright arcs along the morning edge of the planet. Occasionally all the dust will settle out of the atmosphere and Mars' atmosphere appears quite clear in these filters. This phenomenon is called a "violet clearing." When you see this happen, the martian atmosphere is exceptionally calm and transparent.

Besides monitoring the atmosphere for dust, be on the lookout for clouds and hazes that show up when viewed through blue and violet filters.

All of these filters working in concert let you create a global weather picture. However, different areas of Mars will tend to show some features more often than others, which tells you a bit about martian geography. As Mars turns during a day that's slightly longer than ours, the Red Planet's topography will slowly parade in front of your eyes, each night presenting a slightly different starting point for touring.

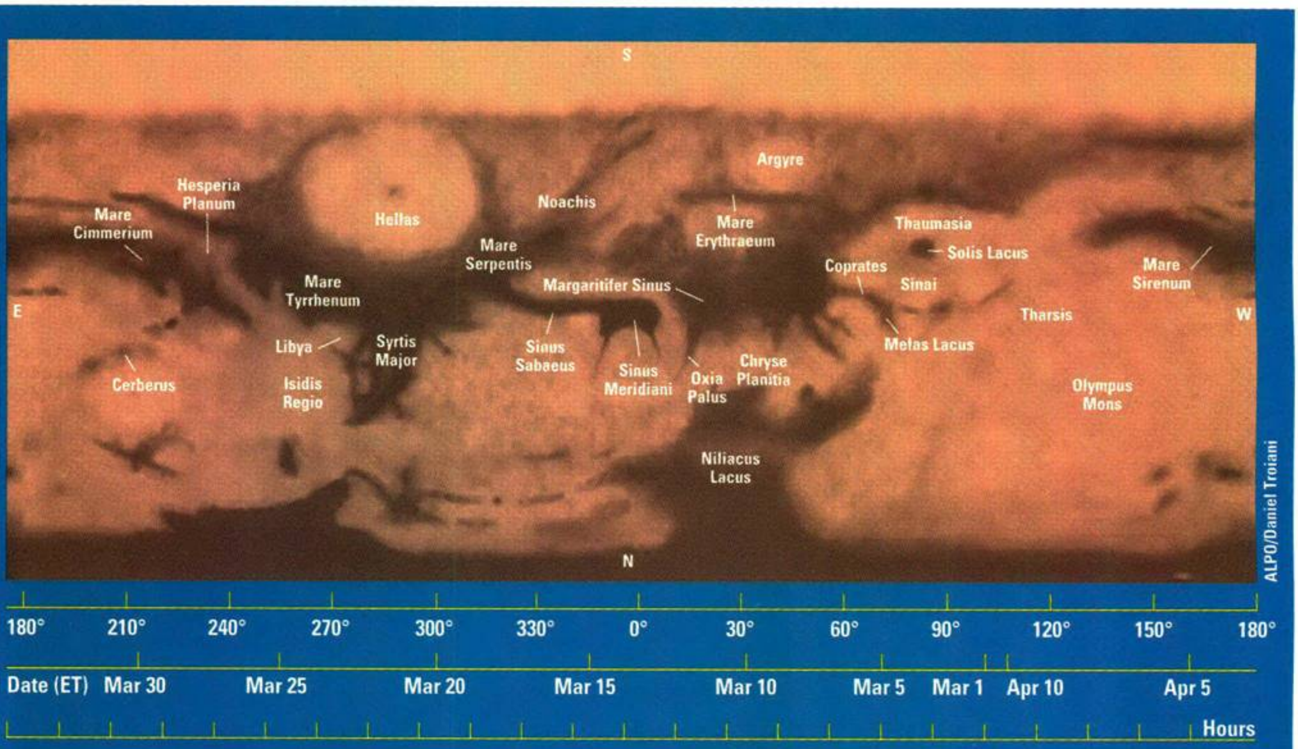
What's Up On Mars Tonight?

The first thing that will strike you when you look at Mars this spring will be its bright polar cap. By opposition, the cap is well on its way to sublimating its carbon dioxide ice to leave a permanent underlayer of water ice.

As the shrinking polar cap dumps more gas into the atmosphere, expect to see increased cloud and haze activity. Applying green, blue, or violet filters will help you discern the polar cap from clouds or haze.

After the white polar cap, the next most obvious features are the darker regions with Latin designations for lakes (lacus), bays (sinus), and seas (mare). More than 100 years ago, the Italian astronomer Giovanni Schiaparelli named most of the maria and other features we see in a telescope. He dubbed Mars' central meridian, its 0° longitude, Sinus Meridiani.

Longitude increases as you move to the west, or to the right on the accompanying map. It shows south at top, an orientation seen through most telescopes. Mars' rotation will cause everything to rotate off the leftmost side of the visible disk at a rate of 14.6° per hour. This is the sunset limb of


S
Argyre
Hesperia Planum
Mare Cimmerium
Hellas
Noachis
Mare Erythraeum
Thaumasia
Solis Lacus
Mare Serpentis
Coprates
Sinai
Mare Sirenum
Mare Tyrrhenum
Margaritifer Sinus
E
Tharsis
W
Libya
Syrtis Major
Sinus Sabaeus
Melas Lacus
Sinus Meridiani
Chryse Planitia
Oxia Palus
Cerberus
Isidis Regio
Olympus Mons
Niliacus Lacus
N
180°
210°
240°
270°
300°
330°
0°
30°
60°
90°
120°
150°
180°
Date (ET)
Mar 30
Mar 25
Mar 20
Mar 15
Mar 10
Mar 5
Mar 1
Apr 10
Apr 5
Hours

ALPO/Daniel Troiani

Determine what longitude of Mars is visible by noting what features lie directly above a given date on the map. The date marks line up with what's on the central meridian at 7 p.m. Eastern Time (6 p.m. Central, 5 p.m. Mountain, 4 p.m. Pacific, and 0h Universal Time the next day). Shift one hour tick mark to the right for each hour after 7 p.m. ET, an hour tick mark to the left for each hour before 7 p.m. ET.

Mars. The right-hand limb, the sunrise side, is where you'll find most morning hazes.

Let's start a global tour at Sinus Meridiani, a logical place since it marks zero longitude on Mars. Through a red filter, Meridiani appears as the elongated bowl, with two north-facing knobs on each end. These are quite visible under good seeing conditions.

Taken together with nearby Sinus Sabaeus, which lies to the east, this region along the equator takes on the appearance of a giant pipe. Look to the south for a light plain called Noachis, which adjoins a dark feature called Mare Serpentis to the east that runs northeast to connect with Sabaeus. Serpentis points to Syrtis Major, perhaps one of the most noticeable dark features on Mars, looking very much like the shape of Africa.

Slipping into view as Syrtis Major and the pipe head toward dusk are Mare Erythraeum and Margaritifer Sinus. The northern margin of this region breaks into a myriad of microstructures that sticks out into lighter plains. On the eastern end of the Margaritifer Sinus, look for tiny, triangular Oxia Palus, which extends northward. This feature becomes prominent when the seeing in our atmosphere becomes steady.

To the northwest, Margaritifer Sinus butts into Chryse Planitia, which is where Viking 1 touched down on July 20, 1976. Look below (north) of Chryse for the great dark region Niliacus Lacus, one of the more prominent features in the northern hemisphere. At times you can see extensions projecting west from it.

A Grand Canyon and the Eye

Redirecting our gaze to the southern ramparts of Erythraeum, we happen across the impact basin Argyre, placed just above a dark patch of mare. This vast basin, 1,100 miles in diameter, has one of the lower elevations on Mars.

Continuing west, we come upon the signature of a great canyon called Valles Marineris, so named after its discovery by Mariner 9 in 1971. If placed on Earth, this gigantic canyon would stretch from New York to San Francisco. Enough material could fill this chasm, a rift caused when Mars' crust cooled and shrank, to make an asteroid 150 miles in diameter. Ice fogs and hazes fill its eastern end during the northern summer.

While we don't really see the canyon, we do detect a change of terrain in the dark features Coprates and Melas Lacus, which jut from the western side of Mare Erythraeum. These dark splotches also outline the lower edge of what some observers call "the Eye of Mars." Solis Lacus is the Eye's pupil, surrounded by the lighter plains of Sinai and Thaumasia.

The Eye's constantly-changing shape is a good weather indicator; you may even see dust storms originate in its area. Storms that shuffle dust around cause its shape to go from elongated east-west to elongated north-south. Presently it's fairly round.

As the Eye swings off of meridian, we gaze west upon the relatively bland Tharsis Bulge, a region dominated by great, dormant volcanos first imaged by Mariner 9 in 1971. Look for what are called orographic clouds around these great mountains, not unlike the clouds we see forming around mountains here on Earth.

The greatest of the Tharsis volcanos is Olympus Mons, which stands 15 miles high, three times the height of Mount Everest, and covers 480 miles at its base. Despite its huge size, this volcano and others are invisible to observers, only hinted at by the clouds that form around them as the martian day progresses.

Along the southern fringe of this seemingly blank region are the "Big Three" dark maria of Tyrrhenum, Cimmerium and Sirenum. A steady night at high power might reveal some subtleties that lie north of the big three; last opposition, keen eyes glimpsed the faint markings of Cerberus. Also, look for the light-colored finger of Hesperia Planum, which splits Mare Tyrrhenum from Mare Cimmerium. When these prominent maria amble across the meridian, keep an eye out for Syrtis Major along the morning limb.

Preceding Syrtis Major is a bright pocket called Isidis Regio. Use a blue or green filter to look for yellowish clouds and whitish clouds both here and toward Libya to the south. A blue cloud that looks green in a yellow filter also forms during this season over Syrtis Major.

The greatest of the Tharsis volcanos is Olympus Mons, which rises 15 miles above the plains of Mars, three times the height of Earth's Mount Everest.

South of Syrtis Major lies the great Hellas basin, some 1,400 miles in diameter. The floor of this basin lies three miles below the average surface elevation on Mars. At certain times of the martian year, air pressure in this area might be high enough to sustain traces of liquid water. This condenses out into such a bright frost that some observers have drawn Mars with two polar caps — Hellas was the other cap.

This brings us back to Sinus Meridiani, where we started. Unless you stay up all night, it takes the better part of 39 days to see all these martian features. Tenacious Mars observers may track two or more rotations of the planet this spring.

One for the History Books

One project you can undertake during this opposition is to archive your views of Mars with drawings. As your eye gets trained you'll catch finer and finer detail. Make up a drawing sheet that includes important statistics like time, date, eyepiece and filters used, plus a section for comments.

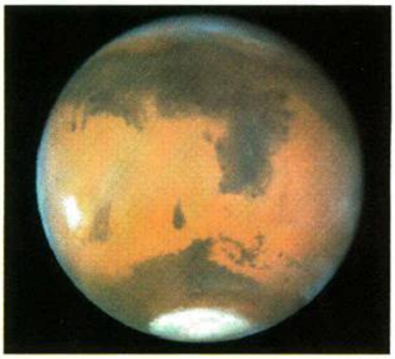
Beyond creating a permanent record, drawing the disk of Mars might even allow you to contribute to humanity's return to the planet. For one, you can keep tabs on how dusty Mars' atmosphere appears, and therefore how warm it is, a critical factor in planning the Mars Pathfinder spacecraft's landing in July.

Working with the Association of Lunar and Planetary Observers, a group of planetary observing enthusiasts, NASA's Jet Propulsion Laboratory has set up a clearinghouse for Mars observations. To find out more, check out the Marswatch site on the Internet at http://mpfwww.jpl.nasa.gov/mpf/marswatch.html.

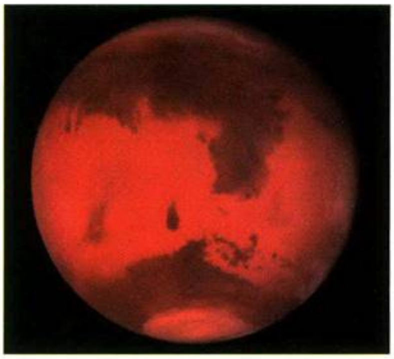
Even if you don't submit observations, you'll still have a front-row seat to history. In 1997, our understanding of the Red Planet is about to undergo a revolution. The allure of life, so long a speculation, calls out across interplanetary space to scientist and layman alike. The pros are answering it with a fusillade of spacecraft. You can answer it from your backyard, through your favorite telescope. ☐

Murray Paulson is an avid planetary observer from St. Albert, Alberta. He made his first martian observations as a teenager during the late 1960s.

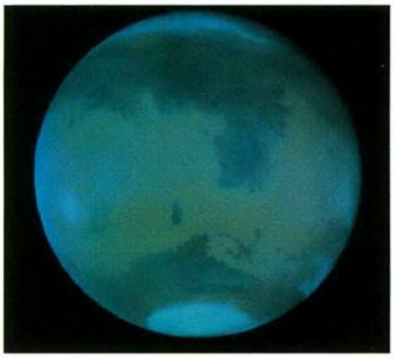
Mars Needs Filters



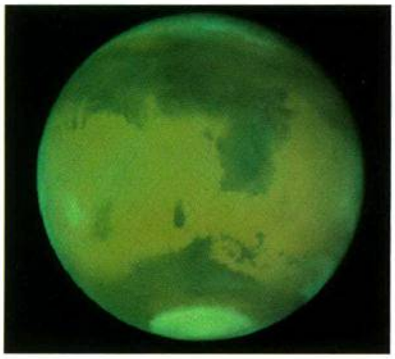
Subtleties hide on an unfiltered Mars.



A red filter reveals rough terrain.



A blue filter highlights high-altitude clouds.

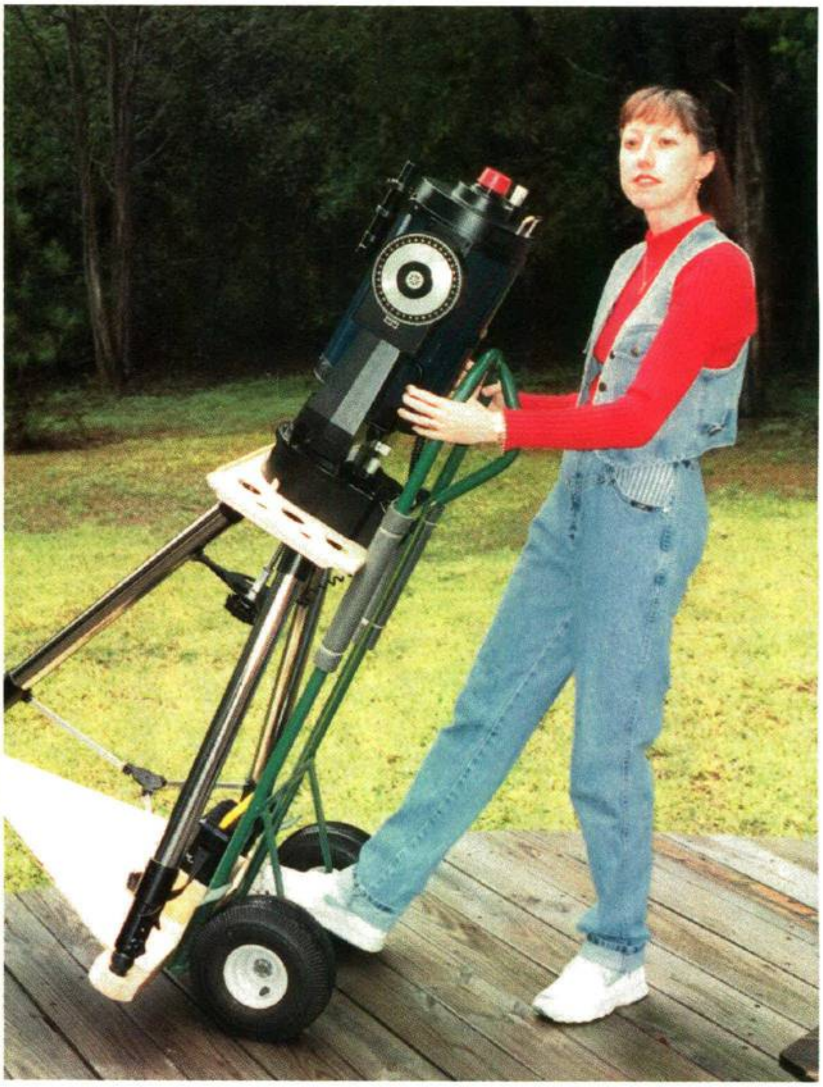


A green filter exposes low-lying clouds.

All photos: STScI/Philip James

Truck Your Scope Around in Style

Moving the common Schmidt-Cassegrain telescope and its accessories becomes a breeze with this tripod base that accepts a hand truck.



Slip in a hand truck to move a 40-pound scope anywhere with ease.

BY ED STEWART

Years of experience has taught me that enthusiasm for observing drops in direct proportion to the effort it takes to set up your equipment. So I've made handling my Schmidt-Cassegrain telescope easier by making a wooden tripod base to hold a power supply and accessories.

Best of all, to head outdoors I just slip a hand truck under one edge of the base and move the entire telescope setup in one trip. These days, I'm up and observing in only a matter of minutes.

Simplicity Works Best

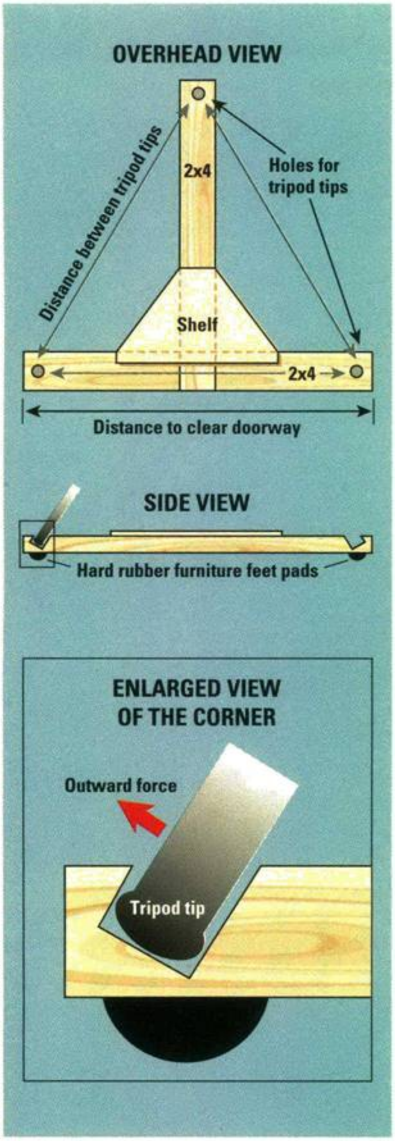
Even though my tripod dolly concept is optimized for a Meade LX200 tripod, you can easily modify the idea to fit any collapsible telescope tripod. The core design requires only two 2x4 boards, a small piece of ½-inch plywood, some screws, wood glue, and a hand truck with soft pneumatic wheels.

The wooden base is nothing more than a T-shaped frame that holds a telescope's tripod. You'll be sliding a hand truck under the top of the T to move everything around. Each tripod leg seats in angled holes drilled on ends of the T-shaped base.

The tripod's built-in tendency to spread outward will force and hold the legs in place inside these holes. For added stability, you'll be gluing a patch of plywood where the 2x4s come together. This could double as a platform for a power supply or whatever other observing accessories you'll need.

Before building the T-shaped base, figure out the tripod's maximum spread. Determine this by measuring the width of the narrowest doorway you must wheel the scope through. Deduct two inches from your measurement to allow for clearance. Cut the 2x4s to this dimension and join them with a simple butt joint. Do this by lining up the 2x4s in a T shape and drilling some pilot holes for two ½"x6" lag screws to secure the horizontal member to the vertical member.

If you are a knowledgeable woodworker and want a stronger joint, use an half-overlap joint. Be sure to allow the additional distance it takes for this joining method.


OVERHEAD VIEW
2x4
Holes for tripod tips
Distance between tripod tips
Shelf
2x4
Distance to clear doorway
SIDE VIEW
Hard rubber furniture feet pads
ENLARGED VIEW OF THE CORNER
Outward force
Tripod tip

ASTRONOMY: Elisabeth Rowan

TRIPOD FRAME PARTS LIST

- (2) 2"x4" pine stud lumber (length depends on spread necessary for tripod legs)
- (1) ½" to ¾" exterior grade plywood sanded one side, approximately 24" x 24" (depending on how many accessories transport with the scope).
- (2) ½" x 6" lay screws, galvanized, with washers
- (10) #10 x 1" flat head wood screws
- Some Woodworker's glue
- (3) Hard rubber furniture knobs or feet
- A Dolly with 10" pneumatic tires (preferred), available at a builder's supply for around $39.95

Before joining the pieces, smooth off any edges to reduce the chances of gouging walls and door frames. I did this by running a ¼" round-over router bit around all the edges.

Next, settle on the plywood shelf's size and shape. It should be big enough to hold a power source and accessories. After determining a size, cut the platform out of ½" to ¾" plywood. Sand off any sharp edges before gluing and screwing it onto the top of the 2"x 4" T-shaped base.

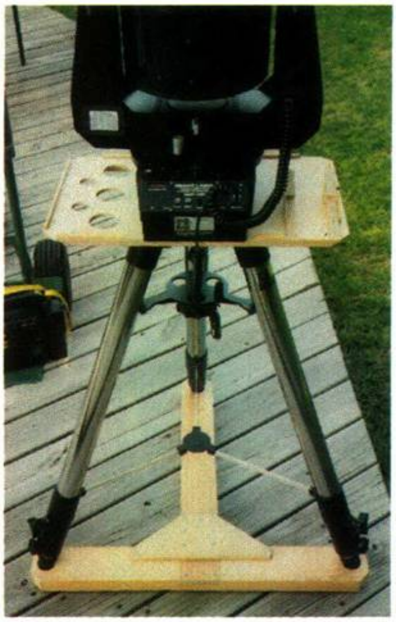
Putting Tripod to Base

Now it's time to drill the holes that accept your tripod. They should be the same diameter as the tip of each tripod leg. Drill them at an angle into the three ends of the T-shape base using a spade bit or by making a number of smaller holes in a circle and chiseling out the centers. The holes must be offset ¼" to ½" toward the center of the T-base to let the tripod legs spread fully outward and seat securely as they slip into each hole.

In the case of my Meade tripod, I knew the holes were drilled properly when the tripod's spreader knob applied enough outward force to lock the leg tips in their holes. If the tripod's spread must be radically reduced to clear a narrow doorway, you might need to replace the original ½" threaded spreader shaft with one several inches longer.

If you own a Celestron Polaris series tripod that doesn't have a spreader assembly, attach a heavy gauge wire from the tripod head to the center of the sled with a turnbuckle. When tightened, the turnbuckle's downward force will lock the legs.

Finally, add some footpads under each of the holes that hold the tripod. These will transfer the weight of the scope directly to the ground and provide clearance for the hand truck's lip to get under the sled for lifting. Finish the frame with varnish or paint to protect it from moisture and to make it look more like a finished part of the scope design.



All photos by the author

A Schmidt-Cassegrain's tripod fits snugly into its wooden T-base.

Once you seat the scope and its tripod into your T-shaped frame, you should never have to worry about tearing down to move outside again. To get outdoors, slip the hand truck under the top of the T frame and tilt the scope back. Everything should fit through narrow doorways like a breeze. Once outdoors, slip out the hand truck and plug everything in to start observing.

Variations on a Theme

As with any telescope making idea, my suggestions are just a starting place. For example, if clearing narrow doorways doesn't present a problem, build a simplified T-frame by cutting two 2x4s several inches longer than the distance between two of the tripod's legs. Nail them at right angles to create a frame that bolts permanently to the hand truck's lip.

To move your scope, simply place its tripod legs into the frame and tip the hand truck back to wheel everything around.

Regardless of how you derive a scope dolly from the basic idea, you'll always enjoy a fundamental recipe for mobility. □

Ed Stewart (elstwrt@austin.cc.tx.us) is an active observer and telescope maker in Austin, Texas. During the day, he teaches desktop publishing at Austin Community College.

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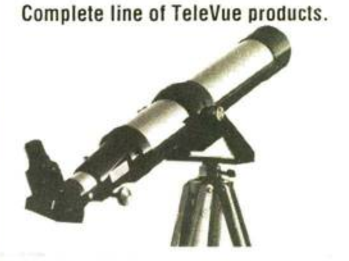

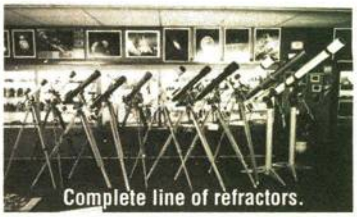
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You told us that the König design just couldn't be improved upon, yet our new König-2 series of 1-1/4" oculars have improved multi-coating and darkened lens edges for breathtaking visual contrast. Special non-reflective black ocular caps. Protective caps on both ocular and barrel ends. The 32mm model uses large 2" lenses set in a 1-1/4" format.
6.5, 8, 12, 16, or 24mm .... Call
32mm, 2" O.D. . $124.95, 55mm Plössl, 2"O.D. . .$119.95

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Right angle or erect image models. **Call for Prices!**

Classic Orthoscopic Eyepieces are still available!

Yes, we are still selling loads of these 4-element orthoscopic eyepieces that in terms of resolution, put some of the expensive occulars sold elsewhere to shame! If you are looking for *maximum resolution, keep the number of elements down to four!* Fully coated with standard filter threads. 1-1/4" O.D. **5, 7, 9, 12.5, 18, or 25mm . . . Call**

The Klee.™ Not just another Barlow!

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These are the original high quality 80mm binoculars we have been selling for years updated with full multi-coating and BAK-4 prisms. Available in 11 or 20 power, they come complete with **case, tripod adapter, central support between the objectives, and collimation certificate.** Don't buy any large binoculars without talking to us first! **11 x 80 or 20 x 80 ......$379.95 ea.**

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Please Note–
Our postage and handling are based on the total value of the order, not per individual item. Just one more way we save you money!

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Mail Order–Simply write us a letter with your requirements. Payment via VISA, MASTERCARD, personal check, or money order.

Guarantee–It has been our policy for the last 30 years to always offer a money-back guarantee on all our items.

All prices and specifications in this ad are subject to change without prior notice. Our phone numbers are **313-665-3575** and **800-521-2828**. Hours are 9:30 a.m. to 5 p.m. EST, Monday thru Friday, 10 a.m. to 3 p.m. on Saturday.

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Available in Brass

Our 8x50 finders come with a 1-1/4" wide-field eyepiece and diagonal. All-metal construction. Fully coated optics........ **Call**

8x50 Erect Image Model. We are now offering our high quality 8x50 finder with a right-angle Amici prism. Now you can read your star charts directly as you aim your telescope. No more confusing images! Once you try it, you'll never go back to reversed images .... **Call**

***CCD Cookbook* Camera Parts— build your own high-performance camera!**

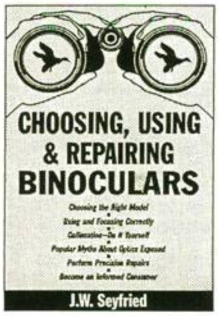
University Optics is offering a fully machined and superbly finished camera head aluminum parts set for ***The CCD Camera Cookbook***. Screwdriver assembly saves you hours and hours—makes building the camera a real joy. Please specify if building the 211- or 245-chip model. **Parts set $89.95**

Have your own lathe and milling machine? Even our unfinished aluminum components set can save you hours of precious time. Two special castings and all the right size aluminum stock needed for the camera head. **Phone, FAX, or write for latest parts list!**

The CCD Camera Cookbook by Berry, Kanton, and Munger. This is the book that **is destined to start the "do-it-yourself CCD revolution"!** Build a CCD camera that connects directly to your computer. Complete step-by-step instructions. Includes IBM-PC software to make it all happen. **Only .... $29.95 ppd.**

Electrical Parts for CCD Camera

We carry in stock the TC-245 and TC-211 chips as well as other electrical components needed to assemble the camera kit. Please call or write for current prices.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Choosing the Right Model
Using and Focusing Correctly
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Popular Myths About Optics Exposed
Perform Precision Repairs
Become an Informed Consumer
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Choosing, Using, and Repairing Binoculars
by J. W. Seyfried

In this new book, every aspect of binocular design, usage, and repair is clearly explained. 55 illustrations and photos show you how to disassemble, optically align, and test your glass.

Build your own collimator! We show you how. Many folk never learned how to focus a binocular for optimum performance. Learn how! Never before published information on quality standards. What to look for when buying a binocular. Binocular myths exposed! ***Choosing, Using & Repairing Binoculars*** is an absolute wealth of information for the astronomer, naturalist, and sportsman. Softbound. 175 pages. **$19.95 ppd.**

WRITE NO. 48 ON THE READER SERVICE CARD

NEW PRODUCTS

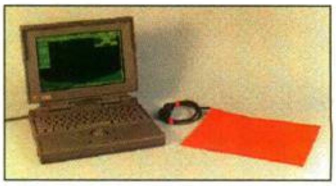
Economical Reflectors and Refractors

International Optics offers the Voyager 90mm (3.6-inch) f/11 refractor and the Voyager 4½-inch f/8 reflecting telescope. Both seamless aluminum tube assemblies are fitted with 1¼-inch rack-and-pinion focusers and 6x30 finderscopes. Each scope sits on an equatorial mount equipped with setting circles, counterweights, an accessory tray, slow motion controls for both axes, and an adjustable declination axis that accommodates different latitudes. Everything fits on an adjustable aluminum tripod.

A 1¼-inch-diameter, 25mm eyepiece that's included with both telescopes yields 40x in the refractor and 36x in the reflector. The refractor ships with a star diagonal and has a multicoated achromatic objective lens to increase contrast. Optional accessories include a 9mm eyepiece, a 2x Barlow lens, a camera adapter, a Moon filter, a motorized clock drive, and an erecting prism for terrestrial viewing. Both scopes come with a one year warranty.

International Optics, P. O. Box 6475, Nashua, NH 03063-6475; voice or fax, (603) 595-7978; e-mail, 73554.3420@compuserve.com. The Voyager 90mm Refractor: $499; the Voyager 4½-inch Reflector: $399. Shipping charges are extra.

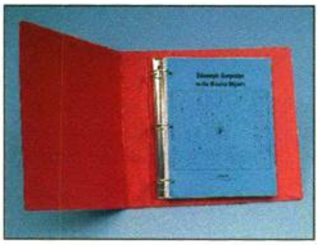
New Products presents announcements issued by manufacturers. ASTRONOMY assumes no responsibility for the product information supplied. Prices are retail. Suppliers should send announcements and color photographs to the attention of John Shibley, P.O. Box 1612, Waukesha, WI 53187, or newprod@astronomy.com



Dew-Fighting Accessories

Jim Kendrick Studio adds three items to its line of dew-fighting accessories. The flexible laptop computer heater is a heating pad that sits under a computer or sandwiches between the keyboard and screen when the computer's not in use. Its power cord features an in-line on/off switch and a cigarette lighter plug. The LX200 control pad heater rubber bands to a control paddle to prevent its display and controls from slowing down in cold weather. The pad plugs into a standard Kendrick power controller. The Kendrick Power-Pack is a 12-volt, 12-amp-hour rechargeable battery with canvas carrying case and shoulder strap. Its cigarette lighter socket is fused to prevent battery damage from short circuits. Total weight is 13 pounds.

Jim Kendrick Studio, 2775 Dundas Street West, Toronto, Ontario, Canada, M6P 1Y4; (416) 762-7946; fax, (416) 767-4112. The Laptop Computer Heater: $120; the LX200 Control Pad Heater: $35; the Kendrick Power-Pack: $35. Shipping and handling are extra.



Messier Companion

Each of the Messier catalog's 110 deep-sky objects has a page devoted to it in the *Telescopic Companion to the Messier Objects*. Each page presents five charts based on photographs for an object. A 30° finder chart shows north at the top and stars down to 7th magnitude to let you find the object in a constellation. Two finderscope charts, both with south at top and one mirror-reversed for finders that use a diagonal, present a 6° field with stars down to 10th magnitude. The last two charts (south at top, one mirror-reversed) crop close on the object to aid in identification and field drawing. Elsewhere on the page is technical information on the object, such as celestial coordinates, brightness, and size, plus room to jot down observations. The 120-page Telescopic Companion comes punched with holes to fit a three-ring binder you provide.

Fells Handicrafts, 5610-49A St., Vegerville, Alberta, Canada, T9C 1K4; (403) 632-3316; e-mail: rfell@agt.net. The Telescopic Companion to the Messier Objects: $10 plus $7 shipping & handling.

Nighttime Chart Illuminator

The Redscan Mark II Astrolite lays flat on any chart to illuminate a 5" by 5" area with red light. A red bulb built into a powerpack base scatters light through an acrylic screen to light up the page surface evenly. The powerpack also holds four AA batteries, two that power the bulb and another pair that serves as a back-up. Flip the power switch left or right of its center "off" position to access one set of batteries or the other. Redscan Mark II Astrolite comes with batteries, an extra red bulb, and a cotton carrying bag with a flap that seals.

APM, Markus Ludes, Kappellenstrasse 1, D-66507 Reifenberg, Germany; 011-49-06375-6345; fax, 011-49-06375-6397. The Redscan Mark II Astrolite: $49.50, plus $5.50 shipping and handling.

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Authorized Meade Dealer

Hardly a day goes by that we don't get a note like the one reprinted below, or a call that goes something like this: "Your ads are right. So and so on the East Coast advertises low prices – but they don't have what I want in stock, they couldn't answer *any* of my questions, and they wanted my credit card number before they'd even *talk* to me. They said if I wanted to ask questions, I should call the manufacturer . . . and then they hung up on me!" One of our customers added, "If I wanted that kind of abuse, I would have called my ex-wife."

You need more than a camera store clerk with a price list and a wild guess to help you pick the right scope. You need someone who will take the time to listen to what *you* need, someone with the experience to help *you* get the most scope for your dollar. We've been helping people choose the right scope since 1979 at ***astronomics***. We *have* the experience to help you pick the scope and accessories that best fit your needs . . . *and your budget.* With scopes from $329 to $40,000 – Meade, Celestron, TeleVue, Takahashi, Questar, and more – we have *all* the right stuff. We may not have the perfect scope for everyone, but we'll do our best to help *you* pick the right scope from the 75 models we carry.

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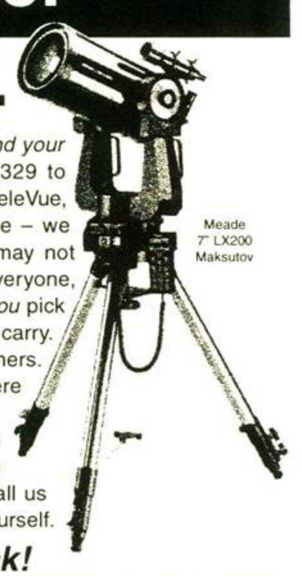

Meade 7" LX200 Maksutov

Meade Advanced Products, Dobsonians, accessories – *in stock!*

Whether it's the computerized 7" LX200 Maksutov shown above; the new LX-10 or 3.5" ETX; or just an accessory like an eyepiece, a filter, a Barlow, or a Magellan computer – if Meade is shipping it for a dealer to keep in stock, the chances are good we *have* it in stock.

Meade prices are about the same anywhere you call. So there's no sense in buying from a dealer who charges your credit card, then makes you wait until he gets around to ordering what you want. Not when you can get what you want *right now* . . . from ***astronomics.***

New products worth a look – from L-5, Takahashi, Megastar, Optec, and more!

The **L-5 Systems JC524**, shown to the left, is a 24" f/3.8 split ring equatorial reflector with a go-to computer drive – at a price nearly $10,000 less than another manufacturer's 25" model. At $14,900, plus crating and shipping, the JC524 is not exactly cheap, but it may be one of the best buys in astronomy!

We have the new **Megastar** version 3.0 CD-ROM observing software in stock. It includes the 19,000,000 object Hubble Guide Star catalog, planets, comets, asteroids, full LX200 scope control, one of the most customizable screen display and chart printing systems around – and a bargain price of only $129!

We have the **Kendrick Dew Remover System** in stock. It includes flexible dew caps and heaters for eyepieces, finders, and telescopes. From the Telrad to the 3.5" Meade ETX to the Celestron CG-14 . . . and all scopes in between. Heaters to keep dew from frying your laptop and cold from slowing down LX200 hand control, too.

We have **Takahashi fluorite/ED refractors** in stock – the 3.1" FS-78EN on the EM-2 mount; the 4" FS-102H on the EM-10 dual axis mount; the 5" FS-128SE on the EM-200 mount, and more.

We have the **Optec f/3.3 Maxfield** in stock starting at $225. It's the sensibly-priced wide-field telecompressor that converts an f/10 SCT into an f/3.3 speed demon for CCD imaging.

We have **ScopeSaver** observing tables for your LX200 tripod – and **ScopeSaver Jr.** alignment plates that make it a cinch for one person to mount an LX200 on its tripod safely!

Celestron 8" Star Hopper Dobsonian

$499

See our Celestron 1¢ Sale ad on page 94.

Celestron 8" Celestar, computerized Celestar, CCD camera – *in stock!*

We have Celestron's DC-drive **Celestar** in stock. At $999, it's the lowest-priced complete 8" Schmidt-Cassegrain made. It's one of our best-sellers, too. We average close to one new and very satified customer per day for this best-buy scope.

We stock the **Celestar Computerized** that can guide you to 10,000 fascinating deep space objects.

We keep Celestron's **Pixcel 255 CCD** autoguider and imager in stock. It's a *very* user-friendly plug and play CCD camera at an affordable $1549. Made exclusively for Celestron by SBIG.

Our free catalog tells how to pick the right Celestron, Meade, Questar, Takahashi, or TeleVue.

Call us at (405) 364-0858, or E-Mail us at Compuserve or AOL, for your *free* copy of our catalog 96AST covering all of the telescopes and accessories we stock – from Celestron, DayStar, Edmund, JMI, Kendrick, L-5 Systems, Lumicon, Meade, Optec, Questar, Rigel Systems, SBIG, Software Bisque, Takahashi, TeleVue, and more. We'll include our 8-page guide on how to pick the right scope and your discount prices on the hundreds of products we carry (sorry, U. S. sales only). The catalog is yours for only the cost of a one minute phone call. The information we send will make it the most useful and informative one minute you'll ever invest in astronomy.

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Color band - blue. Class "A" filters are made with the same premium quality polished glass and multi-alloy coating as Class "B". An additional steel alloy added to the coating process makes our Class "A" filters extremely scratch and fade resistant. Excellent for visual and photographic use. Light transmission is 1/1000th of 1%.

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Color band - white. Class "B" filters are made with polished glass and multi-alloy coating. These filters offer great durability and will provide many years of service and enjoyment with normal use. Can be used visually and for photography. Light transmission is 1/1000th of 1%.

CLASS "C"
Color band - red. Class "C: filters are specifically coated to a lighter density (ND-4). They are for photographic use only. This filter is intended for use by professionals and serious hobbyists. Light transmission is 1/100th of 1%.

ORDERING INFORMATION
1. State scope brand and model number, aperture and outside diameter with filter class and price.
2. Make check or money order payable to J.M.B. Inc. All foreign checks must be payable through a U.S. bank.
3. Shipped free within the continental United States. All others add $5.50 Shipping and Handling per filter. Michigan residents add 6% sales tax. Allow 2-3 weeks for delivery.

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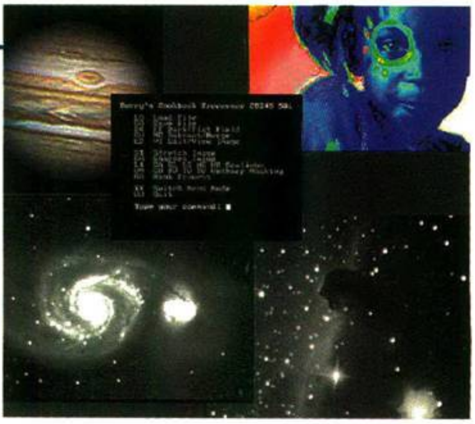
ASTRO BYTES



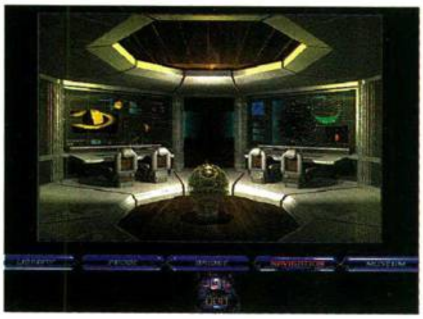
Cookbook Camera Goodies

CB245 is image-processing software for Cookbook 211 and Cookbook 245 CCD Cameras. *CB245* performs dark-frame subtraction and automatic matching, flat-fielding, rank processing, and more. Files can be saved in standard FITS and TIFF image formats.

Multi245 lets you create deep images from a sequence of short integrations with its "Track-and-Stack" command. For instance, shoot twenty 60-second integrations and stack the sequence in order to have the equivalent of a 20-minute integration. *Multi245* supports both manual and automatic star tracking. With this program, users can produce movies of comet and asteroid motion. Contact the developer or visit the website for more information.

Color245 makes color pictures from three color-filtered images taken with the Cookbook 245 and 211 CCD Cameras and creates a 24-bit TIFF or 24-bit BMP color image file. With a standard PC's standard VGA card, you can create publication quality output. Fine-tune the color balance of the celestial object you imaged for a true-color representation, as well as resizing, equalizing, and co-registering three source images without changing the original files.

Richard Berry, 22614 N. Santiam Highway, Lyons, OR 97358, (503) 859-3030, email rberry@wvi.com, website: http://wvi.com/~rberry/. Price: $49.95 each. The programs can be run in a DOS window under Windows 3.1 or Windows 95.



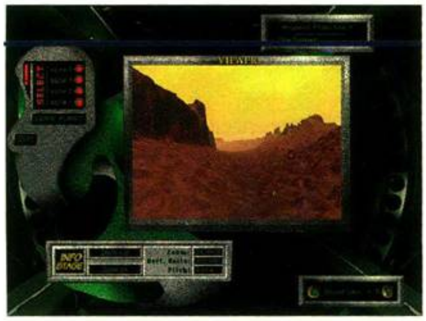
Solar System Explorer

Your mission — Explore the planets. You are a pilot, scientist, and researcher among the wonders of the solar system. With *Solar System Explorer,* plan and navigate your own course through planets and moons, or recreate past missions of famous space probes. The "spaceship" Explorer allows the user to investigate different characteristics of the planets, including geologies, chemistries, and magnetic orientations. *Solar System Explorer's* graphically rich and game-like user interface will engage casual users while delivering more than enough content to delight the most knowledgeable space enthusiast. Color illustrations, animations, photographs, and narratives are incorporated with 360° pan and zoom virtual reality simulations that provide a realistic and scientifically accurate experience.

Consult the *Solar System Explorer* web site to receive updates concerning the space sciences and information on life on Mars.

Maris Multimedia, 4040 Civic Center Drive, Suite 200, San Rafael, CA 94903, (415) 492-2819, fax (415) 492-2867. Website: http://www.maris. com. Price: $29.95 as a multi-platform CD-ROM for Windows-based and Macintosh computers. Price: $45.95. Minimum Windows requirements: 486 SX computer, double-speed CD-ROM drive, 256 color display, 8 MB RAM with at least 3 MB free, and Windows 3.1 (Windows 95 compatible).

Product information is as provided by the developer. Software developers may send new programs and upgrades to AstroBytes, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187-1612 or e-mail bytes@astronomy.com. Check out ASTRONOMY's home page at http://www. kalmbach.com/astro/astronomy.html



Mars Rover

Navigate a virtual spacecraft around the Red Planet with *Mars Rover* from RomTech. This CD-ROM uses terrain data based on NASA's digital maps of Mars and combines fly-throughs over more than 100 different areas on the martian landscape. Stop and sightsee at dozens of places including Noctus Labyrinthus, Gangis Chasma, and Olympus Mons. When the virtual spacecraft is stopped, zoom in and out for a 360° panoramic view. An information icon at each destination brings up NASA photographs and explanations written by NASA scientists.

RomTech, 2945 McMillan Road, Suite 128, San Luis Obispo, CA 93401, (800) 829-8754, fax (800) 355-8597 or (805) 781-2259. Website: http://www.romt.com. Price: $29.95 as a hybrid two-CD set for PC and Macintosh computers. Minimum PC requirements: 486 processor, Windows 3.1, 8 MB RAM and 10 MB hard disk space, and a CD-ROM drive.

The Webweaver Picks

March is Mars month in AstroBytes as the Red Planet reaches opposition on the 20th.

Mars in March Web Sites: (This list is not inclusive)

ALPO's Mars site — http://www.lpl.arizona.edu/~rhill/alpo/mars.html.

Center for Mars Exploration — http://cmex-www.arc.nasa.gov/

JPL's Mars Pathfinder Project — http://mpfwww.jpl.nasa.gov.mpf.marswatch.html

Marswatch — http://astrosun.tn.cornell.edu/marsnet/mnhome.html

Mars Global Surveyor Project — http://mgs-www.jpl.nasa.gov/

NASA's Observatorium — http://observe.ivv.nasa.gov

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- **Charles Scovil**, AAVSO, from the Fairfield County Astronomical Society
- **Bob Berman**, featured columnist at DISCOVER Magazine,
- **J. Kelly Beatty**, Senior Editor of *Sky & Telescope*
- **John Briggs**, from the Yerkes Observatory and the University of Chicago

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- Adirondack Video Astronomy
- Astronomy To Go
- Bob Strong Enterprises
- F.C. Meichsner
- Focus Camera and Video
- Gary Hand (Swap Table)
- Gems of Light
- International Optics
- Kalmbach Publishing
- Kendrick Dew Systems
- Knollwood Books
- Linda Zimmerman Space Art
- Mag 1 Instruments
- Meade Instruments
- Optical Guidance Systems
- Orion Telescopes & Binoculars
- Pocono Mountain Optics
- Project Pluto
- Questar
- Rex's Astro Stuff
- River's Camera Shop
- Roger Tuthill
- Sky Publishing
- Software Bisque
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- Star Stuff
- T&T Binocular Mounts
- Technical Innovations
- Televue Optics
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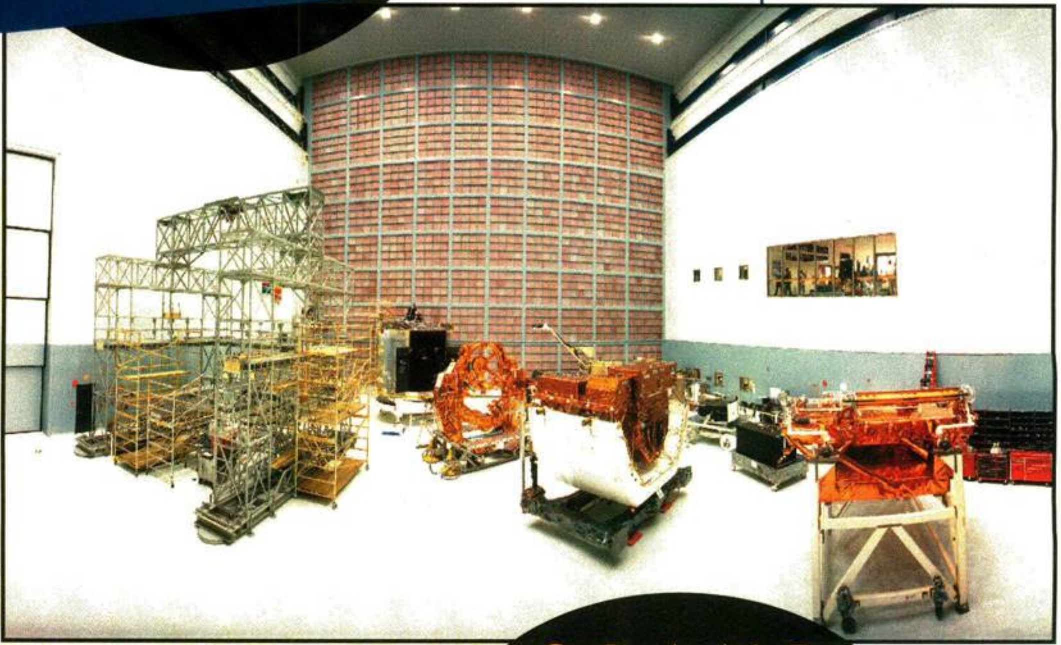

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You may use the Official Entry Form (no reproductions, please) to subscribe to ASTRONOMY, but you do not have to subscribe to enter. Prizes will be awarded once from all entries in June 1997. If the Official Entry Form is missing from this magazine, send a postcard with your name, address, home phone number and this magazine's issue date to:

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Cards must be postmarked by May 31, 1997.

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1. No Purchase Necessary. Official entry forms are bound in the February, March, and April 1997 issues of ASTRONOMY. The 1997 ASTRONOMY Sweepstakes is open to U.S. residents, 18 years of age or older. Employees (and their dependents and immediate household members) of Kalmbach Publishing Co., their advertising and promotional agencies, and sponsoring companies are not eligible to participate.

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3. Prizes and Odds of Winning. One drawing will be held on or about June 15, 1997 for the following awards: One Grand Prize consisting of three days in Washington, DC, for two people. The trip package includes round trip coach airfare from any city in the continental U.S. (Saturday night stay required), two nights first class hotel accommodations (double occupancy), VIP tour of the NASA Goddard Space Flight Center, standard rental car for three days and $300.00 cash for meals (retail value $2,241.00). Winners must travel between July 15, 1997 and November 30, 1997 and travel arrangements must be made at lest 30 days prior to departure date. One First Prize consisting of a $1,000.00 Gift Certificate for a telescope from a retailer selected by the winner. Ten Second Prizes consisting of $100.00 worth of Kalmbach books/calendars/videos selected by the winners. Twenty Third Prizes consisting of a one-year subscription to ASTRONOMY Magazine (retail value $34.95). Any applicable federal, state, and/or local taxes are the responsibility of the winner. Odds of winning depend on the number of entries received. Total circulation for Astronomy is 166, 136. Sweepstakes void where prohibited. Florida residents are eligible for prizes.

4. Validation. Winners in The 1997 ASTRONOMY Sweepstakes will be selected in a random drawing conducted by an independent judging organization whose decisions are final. By entering the sweepstakes, participants agree to be bound by these official rules and all decisions of the judging organization. Sweepstakes entries void if not legible or completed in full, if not obtained legitimately, or forged, photocopied, mechanically reproduced, late, or tampered with. The potential winners may be asked to sign and return an Affidavit of Eligibility and liability/publicity release within seven (7) days of notification. In the event of non-compliance, alternate winners will be randomly drawn. No responsibility is assumed for lost, stolen, misdirected or late mail. All sweepstakes entries become the property of the sponsor and will not be returned.

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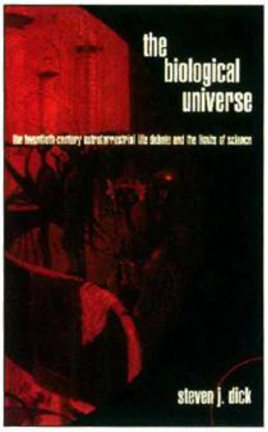
ASTRO BOOKS

The Biological Universe: The Twentieth Century Extraterrestrial Life Debate and the Limits of Science

Steven J. Dick, 578 pages, Cambridge University Press, New York, 1996; ISBN 0-521-34326-7, hardcover, $54.95.

The Biological Universe by Steven Dick admirably fills a gap in the exobiology literature. It is a scholarly, comprehensive history of the entire field, focusing mostly on 20th century developments. Dick, an astronomer and historian of science at the U.S. Naval Observatory, has done his homework well; over 2,000 references grace this book for those interested in further study.


the biological universe
the twentieth-century extraterrestrial life debate and the limits of science
steven j. dick

An introductory chapter reviews historical ideas about extraterrestrial life from classical Greek times to the start of the 20th century. The chapter about life in the solar system provides an excellent history of the martian canals controversy that raged nearly until the Mariner 4 flyby of 1965 (see "The Red Planet's Colorful Past," page 44). This and other similar episodes warns us to be very cautious about accepting evidence for extraterrestrial life. Unfortunately, due to the chapter's focus on Mars, it does not mention the discussion about other potential abodes for life, such as the possible subsurface oceans of Europa.

The chapter on planetary systems contains an excellent history of Peter van de Kamp's now discredited reports of planets orbiting Barnard's Star. But the book was published too soon to incorporate the recent discoveries of several extrasolar planets. The history of origin-of-life experiments receives a balanced and comprehensive treatment.

A later chapter describes how extraterrestrial life appears in science fiction, television, and films. But Dick understates the cultural impact of the media on the public's expectations of a universe populated with intelligent life, in light of the far more pessimistic views of many scientists. The saga of the UFO controversy gives insight into the politics of science. UFOs became a forbidden topic among scientists, most of whom were understandably afraid of investigating the issue in a scientific manner for fear of harming their careers.

The best chapter is the superb history of SETI, covering the first conferences and experiments such as Project Ozma, on to the cancellation of NASA's SETI efforts by Congress and its takeover by private foundations. The major loss of optimism among SETI proponents is especially fascinating. Some ask: "If intelligence is common in the Galaxy, why aren't they here?"

Minor criticisms aside, *The Biological Universe* delivers what it promises: a well-researched, comprehensive, historical perspective on one of the most controversial, yet potentially important, fields of science. The book cites many instances when evidence for extraterrestrial life was overthrown upon further examination. These examples sound a repeated warning that extraordinary claims really do require extraordinary evidence. *The Biological Universe* will be the definitive historical study of its time, and it deserves reading by anyone seriously interested in extraterrestrial life. —*Roger Sauterer*

Other Books

Orbit: NASA Astronauts Photograph the Earth

Jay Apt, Michael Helfert, and Justin Wilkinson, National Geographic Society, Washington, D.C., 1996; ISBN 0-799-3714-5, hardcover, $40; ISBN 0-7922-3715-3, deluxe hardcover edition, $52.

The word "awesome" is one of the most overused words in contemporary American culture, but it applies to this book. More than 100 breathtaking photographs taken from orbit — most of which cover a full page — leave the reader with a sense of awe and wonder. Page after page, you'll find yourself saying "Wow!" The photos have been digitally remastered to show accurate colors. Text and captions, co-authored by shuttle astronaut Jay Apt, describe the various features seen in the photos. The deluxe edition comes with leather binding, gold-edged pages, and a satin book marker.

The Comet Hale-Bopp Book

Thomas Hockey, 175 pages, ATL Press, Shrewsbury, Mass., 1996; ISBN 1-882360-14-1, hardcover, $42.95; ISBN 1-882360-15-X, paper, $19.95.

Hockey, a planetary astronomer at the University of Northern Iowa, clearly explains how to find Hale-Bopp and what sorts of things you should look for. Maps show where the comet will be on different dates. But the book does much more. It also discusses the scientific importance of Hale-Bopp and other comets.

Small Astronomical Observatories

Patrick Moore, editor, 229 pages, Springer-Verlag, New York, 1996; ISBN 3-540-19913-6, paper, $32.95.

This is the fourth installment of Springer-Verlag's Practical Astronomy series. Written by amateur astronomers, this book describes 25 small observatories in the British Isles, the United States, Canada, and South Africa. Easy-to-understand instructions walk the reader through the construction process.

Gems of Hubble

Jacqueline Mitton and Stephen P. Maran, 123 pages, Cambridge University Press, New York, 1996; ISBN 0-521-57100-6, paper, $13.95.

This short book features 60 of the most beautiful Hubble Space Telescope images, showing a tremendous variety of objects, from planets to quasars. The one- to four-paragraph captions describe the scientific importance of each image. ☐

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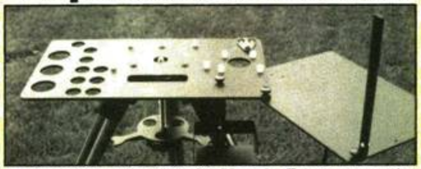

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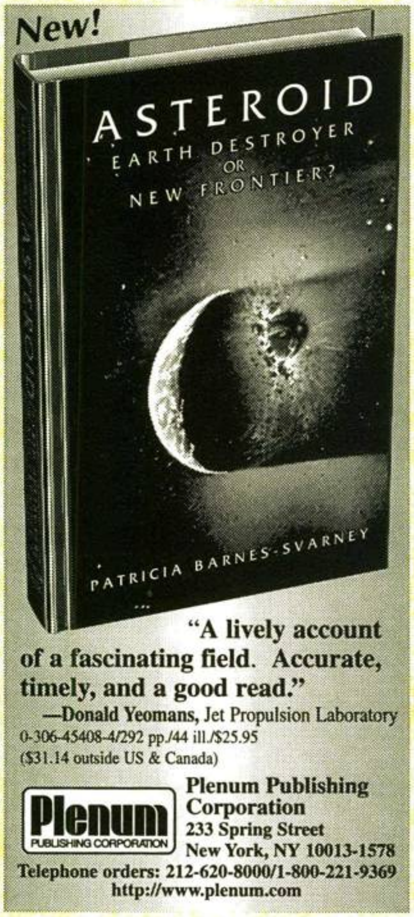

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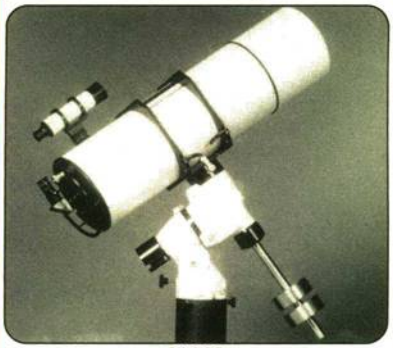

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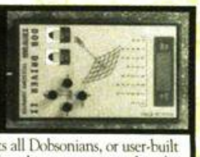

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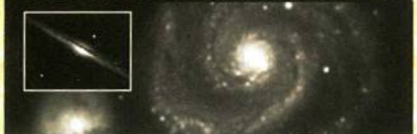

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March 7-9
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March 15
Second Annual Montana Astro Fair, Museum of the Rockies and Taylor Planetarium, Bozeman, Montana. Co-sponsored by the Museum and the Southwest Montana Astronomical Society. Contact Mike Murray, Museum of the Rockies, 600 W. Kagy Blvd., Bozeman, MT 59717, (406) 994-6891, ammmm@gemini.oscs.montana.edu.

March 17-21
28th Annual Lunar and Planetary Science Conference, NASA Johnson Space Center, Houston, Texas. Co-sponsored by the Lunar and Planetary Institute and NASA Johnson Space Center. Contact LeBecca Simmons, 3600 Bay Area Blvd., Houston, TX 77058, (713) 486-2158, simmons@lpi.jsc.nasa.gov.

March 22
Astrophoto 12, Moorpark College, Moorpark, California. Contact VCAS, P.O. Box 982, Simi Valley, CA 93062, Dave Holland, (805) 526-4032, vcas@aol.com, www.serve.net/vcas/vcas.html.

March 24-31
Comet Hale-Bopp Caribbean Cruise, aboard the Stella Solaris. Fred Whipple, Robert Berman of National Public Radio's *Skywindow*, and Tom Bopp, co-discoverer of the comet, will be aboard ship. Prices range from $792-$1792, plus airfare. Contact Darlene, (800) 627-1315.

March 28
Ninth Annual Meeting of the International Dark-Sky Assn., Hotel Park, Tucson, Arizona. Contact David Crawford, 3545 N. Stewart Avenue, Tucson, AZ 85716, or IDA, http://www.darksky.org, crawford@darksky.org.

April 4-6
The Beach Party – a star party, St. George Island State Park, Florida. Sponsored by the Tallahassee Astronomical Society. Contact Joe Haley, (904) 386-1874; Henry Freedenberg, henryf@freenet.tlh.fl.us.

April 20
Sixth Annual Northeast Astronomy Forum and Telescope Show, Grand Ballroom, Holiday Inn Conference Center, Suffern, New York. Co-sponsored by ASTRONOMY magazine and the Rockland Astronomy Club. Contact Don Urban, 73 Haring Street, Closter, NJ 07624-1709, (201) 768-6575, durban1@aol.com. □

Please submit club announcements four months in advance to Meetings and Events, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187-1612, or to tconley@astronomy.com.

RESOURCES PHOTOFACTS

Probing the Local Cloud (page 38)

Alchemy of the Heavens, by Ken Croswell (Anchor Books, 1995). Chapter 14 discusses the interstellar medium.

Interstellar Matters, by Gerrit L. Verschuur (Springer-Verlag, 1989). The story of the interstellar medium.

The Red Planet's Colorful Past (page 44)

The Planet Mars: A History of Observation & Discovery, by William Sheehan (University of Arizona Press, 1996). A comprehensive history of the human fascination with Mars.

Lowell and Mars, by William Graves Hoyt (University of Arizona Press, 1976; reprinted 1996). This book offers a detailed account of the Mars canals fiasco.

Choosing the Right Film for Comet Hale-Bopp (page 74)

Astrophotography for the Amateur, by Michael Covington (Cambridge University Press, 1985; revised 1991). An excellent guide for the beginning astrophotographer; chapter 4 discusses comet photography.

A Manual of Advanced Celestial Photography, by Brad D. Wallis and Robert W. Provin (Cambridge University Press, 1988). For the more experienced astrophotographer; includes a section on comets.

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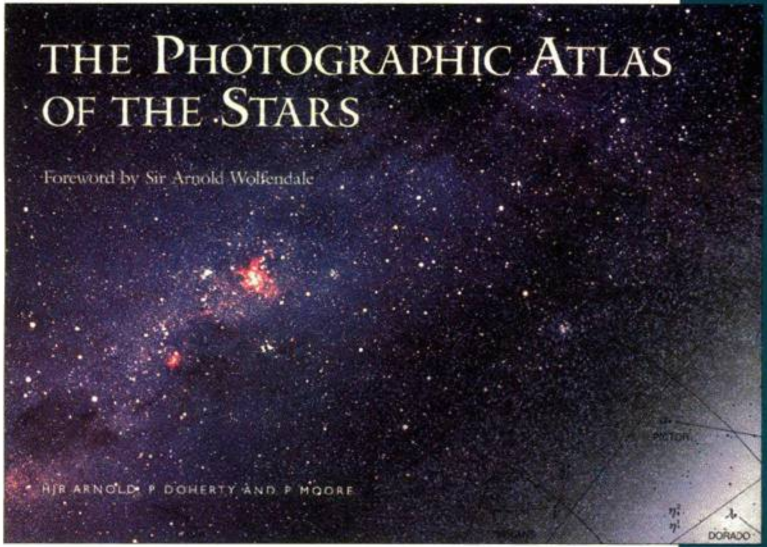
p. 62: Comet Hyakutake close-up, Tom Diana, 4-inch f/5.9 refractor, Konica 3200 film, 10 minutes, March 27, 1996; **p. 69:** NGC 7662, Jack Newton, 16-inch f/5 reflector, Ektachrome 400, 40 minutes; **p. 70, top:** Eclipsed Moon, Thomas R. Perry, 1000mm f/8 lens, Kodacolor 1600 film, 30 seconds, December 9, 1992; **p. 70, bottom:** Mars, Donald Parker, 16-inch f/6 working with eyepiece projection at f/50.3, Lynxx PC CCD camera, combination of exposures shot through a Schott RG610 red filter (0.65-second), a Schott VG9 green filter (7 seconds), and a Schott BG12 blue filter (22 seconds), September 18, 1996; **p. 71, far left:** Star cluster M39, F. A. Sudow, 150mm f/2.8 lens, Ektachrome 400 film, 20 minutes; **p. 71, far right:** Star cluster NGC 752, Jack Metcalfe, 135mm f/4 lens, hypered Tech Pan 2415 film, 20 minutes.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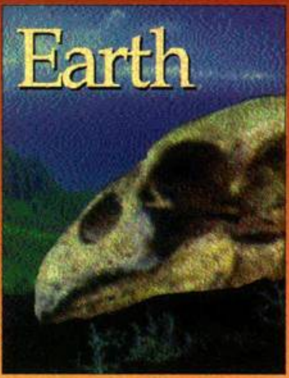

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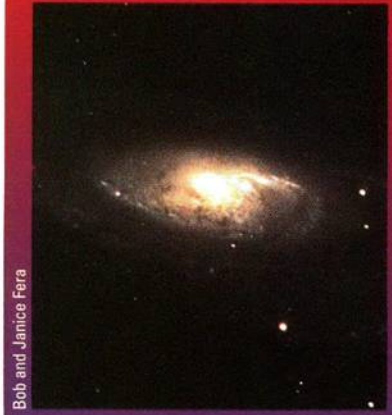
Bob and Janice Fera

DISCOVER THE SPRING SKY
As the warmer nights of spring beckon, break out your small telescope and explore a host of glorious stars, clusters, and galaxies.

A STRANGE PLANETARY ZOO
In the past year, a dozen or so planets have been found orbiting sunlike stars. Join astronomers trying to understand the bewildering diversity of these new planets.

HALE-BOPP ROUNDS THE SUN
The great comet of '97 passes closest to the Sun on April 1, heating the nucleus to a frenzy of activity and creating a spectacular sight in the evening sky.

WHIRLING TIME BOMBS
A blinding flash of gamma rays signals the merger of two neutron stars — and perhaps sounds the death knell for any life within thousands of light-years.

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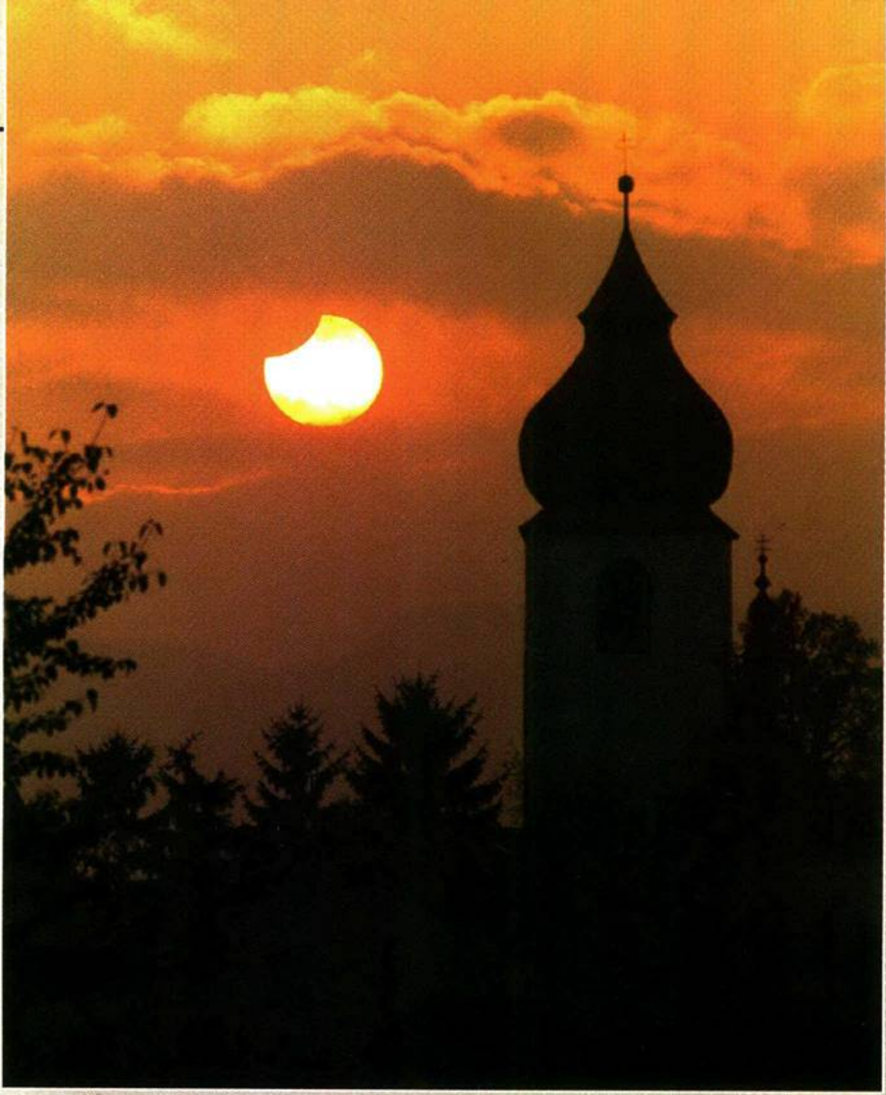
It's not quite like dialing up 1-800-UNIVRSE, but through the Telescopes In Education (TIE) program, you can dial up a 24-inch telescope on California's Mt. Wilson from anywhere in the world to image the sky.

That's been the main goal of TIE since its inception in August 1993. The program, jointly administered by the Mount Wilson Institute and NASA's Jet Propulsion Laboratory, has let more than 250 schools from as far away as Japan, Australia, and England remotely access by modem a CCD camera hooked up to the 24-inch scope. Students use the electronic camera to look for remote asteroids, exploding stars in other galaxies, and faint comets at the edge of our solar system.

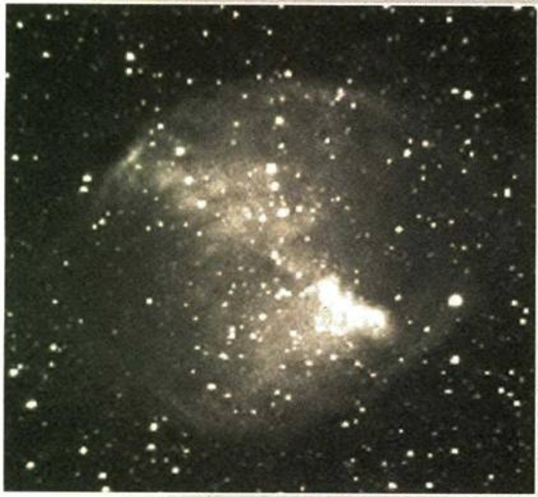
But most groups just enjoy using the telescope to survey deep-sky objects. That's what science teacher Ralph Ford and his 14 junior high students from Manhattan Beach, California, did recently during their three observing runs.

"Our goal with the TIE telescope was to image many different objects to provide students with an understanding of what's out there," he says of his October 1996 sessions. "Each night focused on a particular type of object — globular star clusters, galaxies, planetaries and small nebulae."

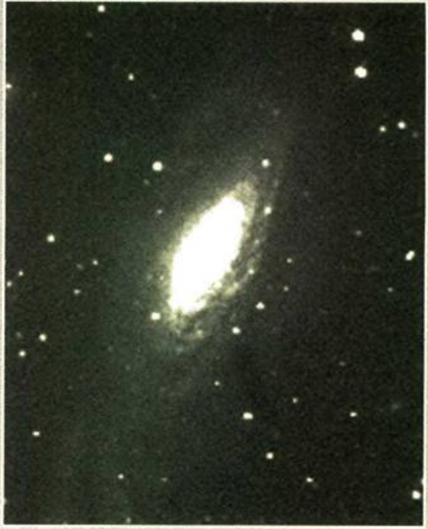
A typical run starts with a phone call to a volunteer



Partial Solar Eclipse over Slovakia, October 12, 1996
Milan Kamenicky
(300mm f/8 lens, Konica VX100 film, 1/125-second exposure)



M27 in Vulpecula
Manhattan Beach, California, Junior High School Science Class
(24-inch f/3.8 TIE telescope, ST6 CCD camera, 15-second exposure)



NGC 7331 in Pegasus
La Jolla High School Astronomy Club
(24-inch f/3.8 TIE telescope, ST6 CCD camera, 30-second exposure)

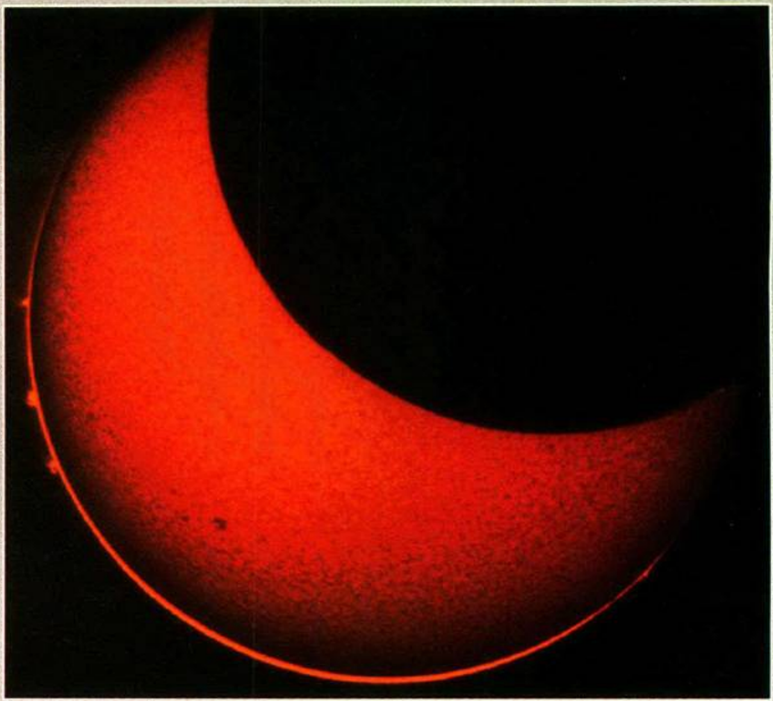
at the observatory who oversees the telescope. When given the OK, observers dial up the telescope by modem using another line. Once connected, the telescope is at the user's command. "I maintained the voice link through a speaker phone so my students could enjoy the clankings and whirrings of a slewing scope," says Ford.

Now TIE coordinators want to take students beyond general imaging. Plans are in place to make a teaching module database available to all educational users. Educators would access the database through a menu of grade levels and topic options, and then download complete lesson plans with supporting digitized images.

Program director Gil Clark is also working to bring students together from across the continents to do research in international teams.

Although TIE's main goal is to provide a free resource to educators, amateur astronomers can also enjoy telescope access on holidays and the weekends for around $50 an hour. Contact TIE care of the Mount Wilson Institute, 740 Holladay Road, Pasadena, CA 91106. Reach them by phone at (818) 793-3100, or access their homepage at http://encke.jpl.nasa.gov/TIE/TIE_index.html. ☐

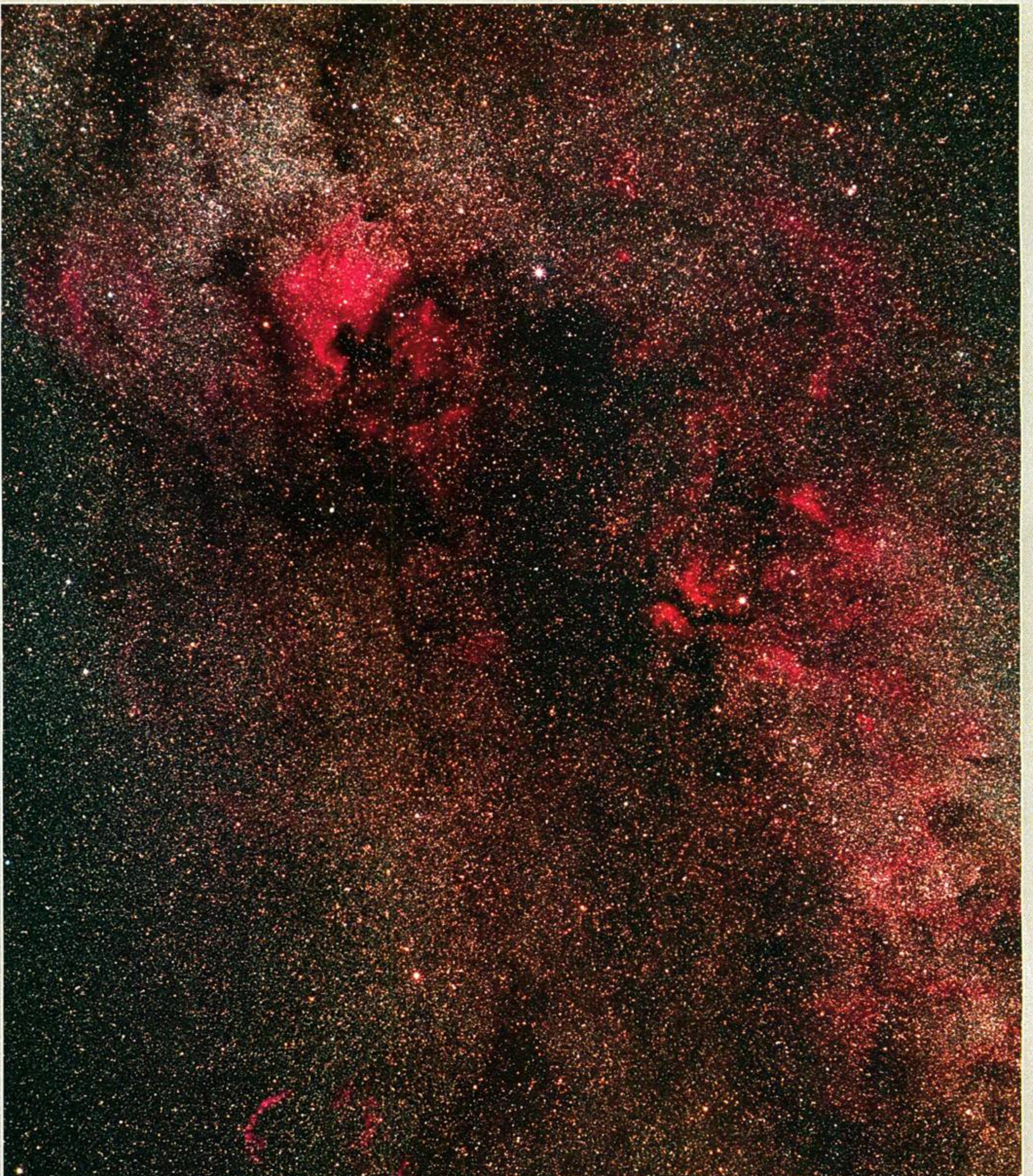
ASTRONOMY wants to share your observations of the sky with readers. Send reports, sketches, photographs, and disks to John Shibley, Reader Reports Editor, ASTRONOMY, P.O. Box 1612, Waukesha, WI 53187-1612. Please label each photo with photo data, name, address, and social security number. You may also send written reports and images via the Internet to: rreports@astronomy.com



Solar Eclipse through an Hα Filter, October 12, 1996
H. J. P. Arnold
(7-inch f/9 refractor, 0.6 Angstrom DayStar solar filter, ¼-second exposure)

Eclipsed Moon over the Rockies, September 26, 1996
Brent Townsend
(50mm f/1.8 lens, Kodak Elite 100 film, 4-second exposure)

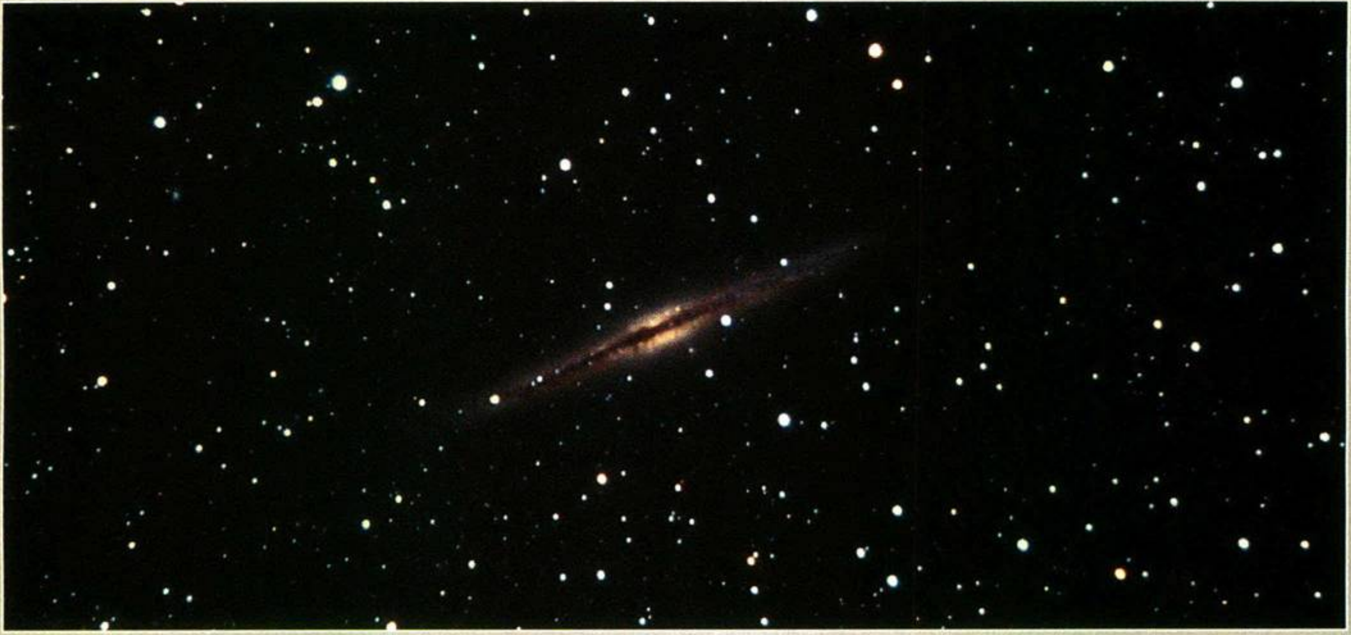
Crescent Moon above a Star Party
Frank Zullo
(55mm f/8 lens, Kodak EPZ film, 1-second exposure)



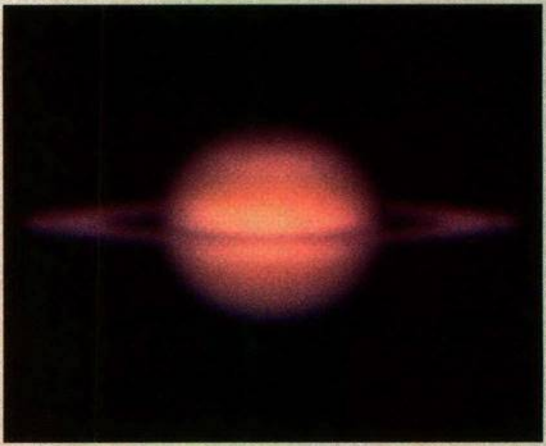
The Spine of Cygnus

Tony and Daphne Hallas

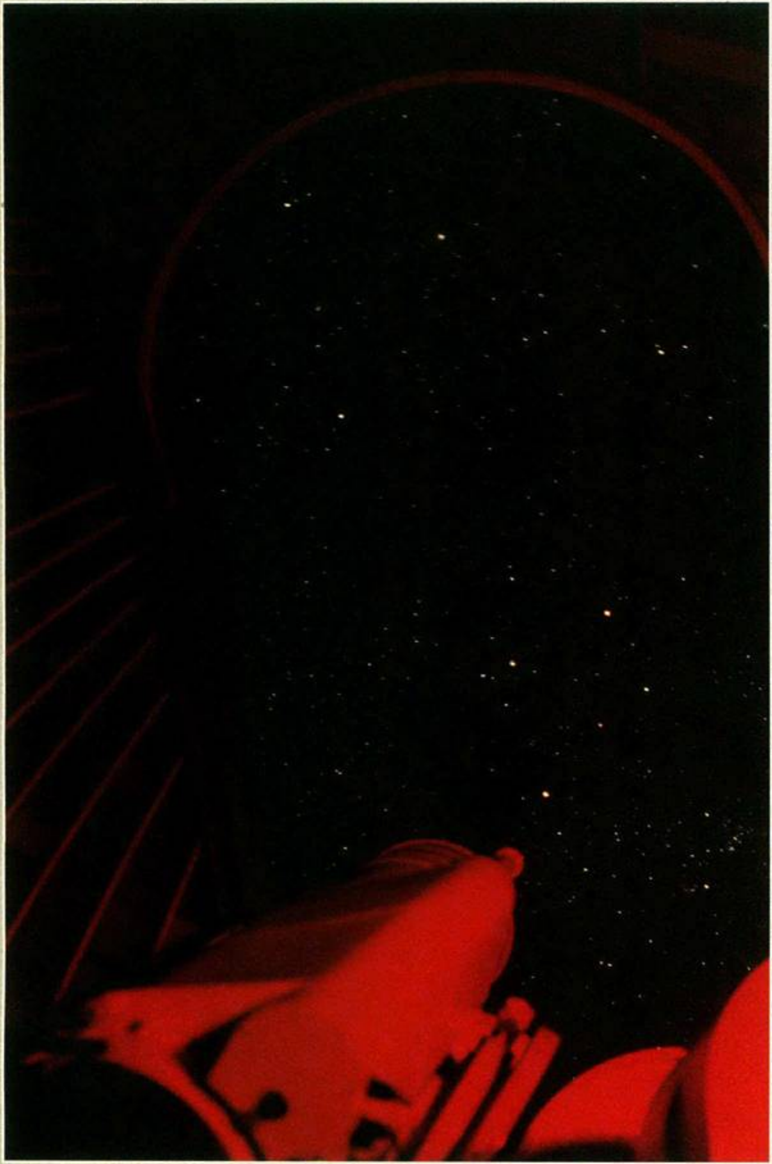
(165mm f/2.8 lens, hypered Fuji SHG 400 film, composite of two 15-minute exposures)



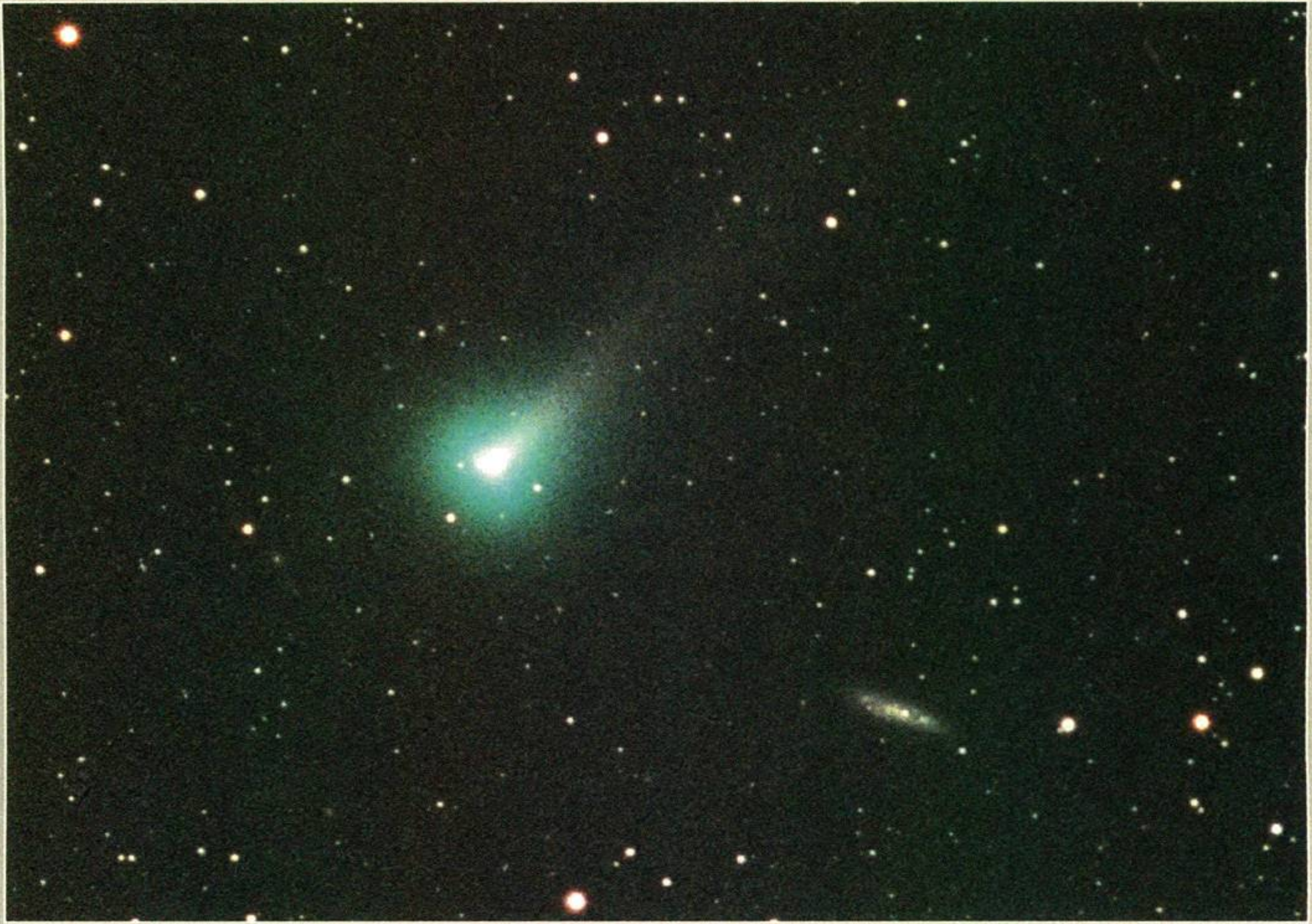
NGC 891 in Andromeda
Bob and Janice Fera
(11-inch f/10 SCT, hypered Kodak PPF 400 film, composite of 60- and 90-minute exposures)



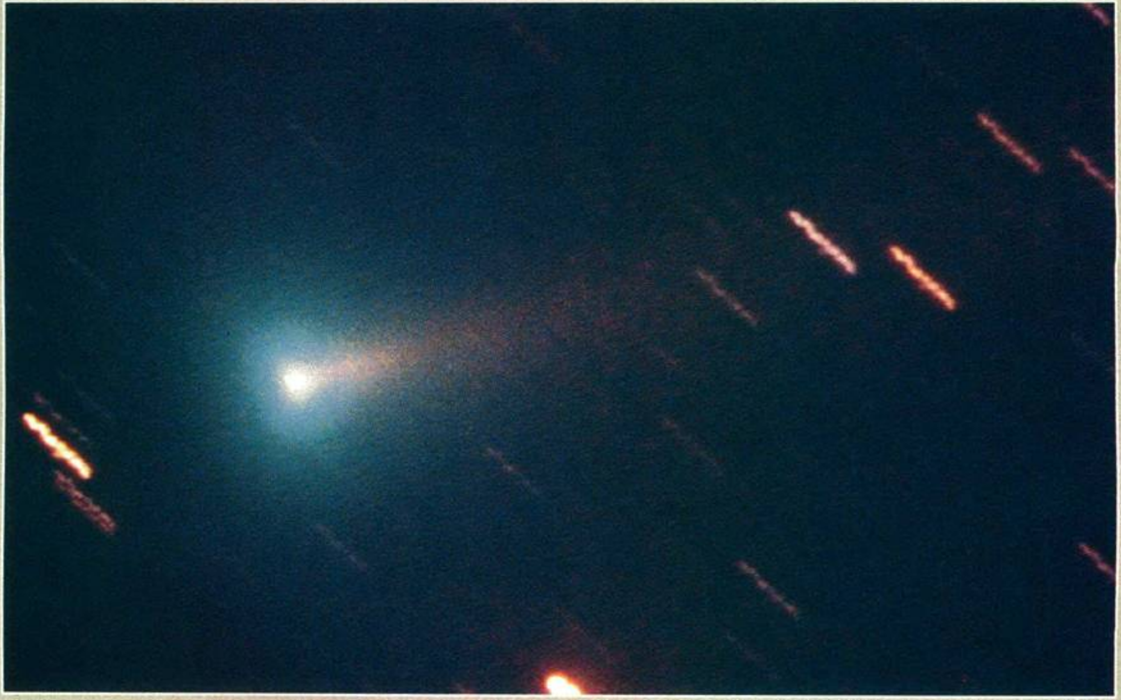
Saturn, September 14, 1996
Alberto Levy
(33-inch Cassegrain at f/70, Ektachrome 100 film, 2-second exposure)



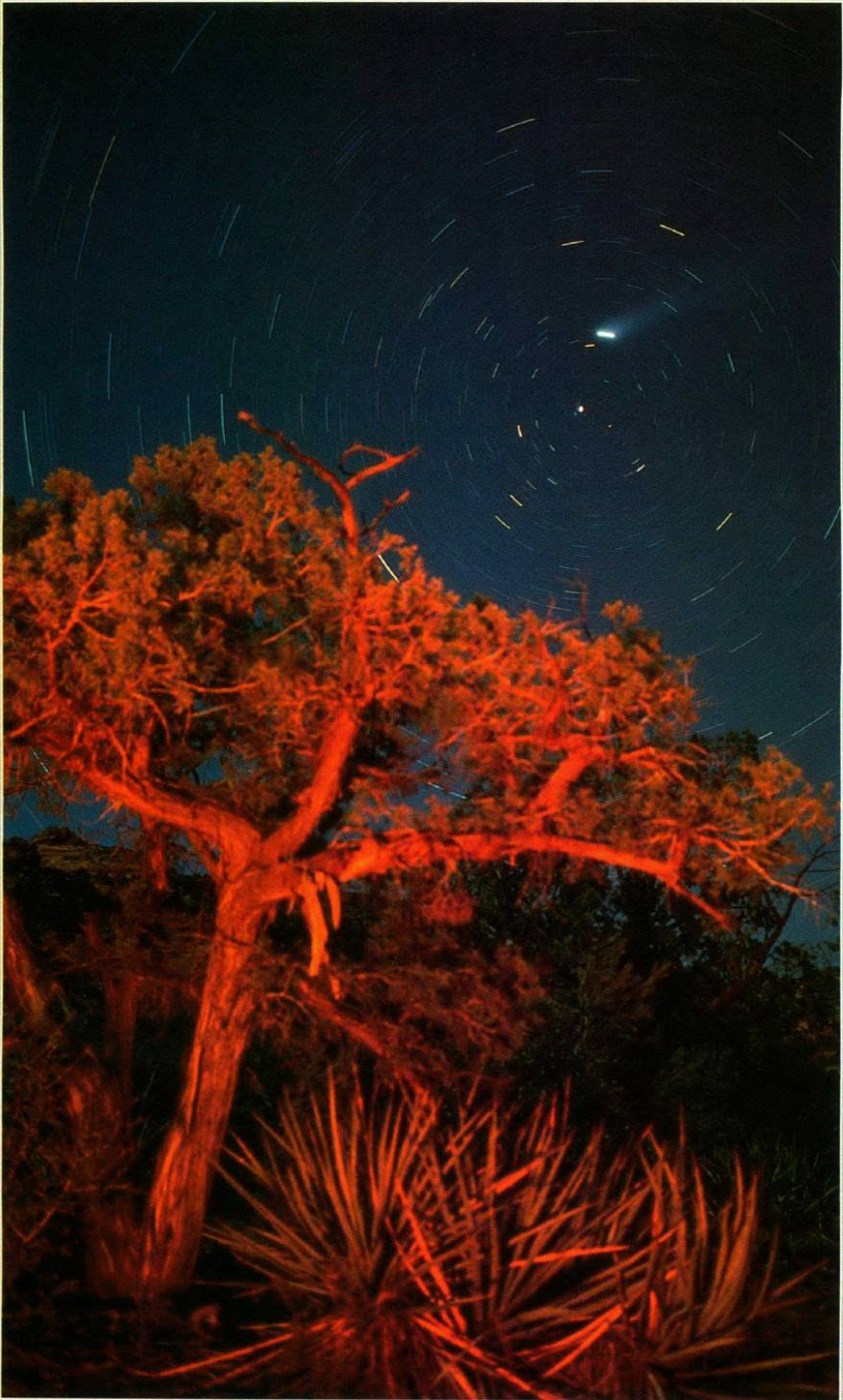
Crux through an Observatory
José Carlos
(50mm f/5.6 lens, Kodak Multispeed 110/1000 film, 50-minute exposure)



Comet Tabur near M108 in Ursa Major
Gerald Rhemann and Franz Kersche
(9-inch f/2 Schmidt camera, Kodak Gold Pro 400, 7-minute exposure)



Comet Tabur on November 8, 1996
James R. Foster
(11-inch f/6.3 SCT, hypered Kodak PPF 400, 15-minute exposure)



Comet Hyakutake behind a Juniper Tree
Dean Howard
(28mm f/2.8 lens, Fujichrome RDP 100 film, 25-minute exposure)

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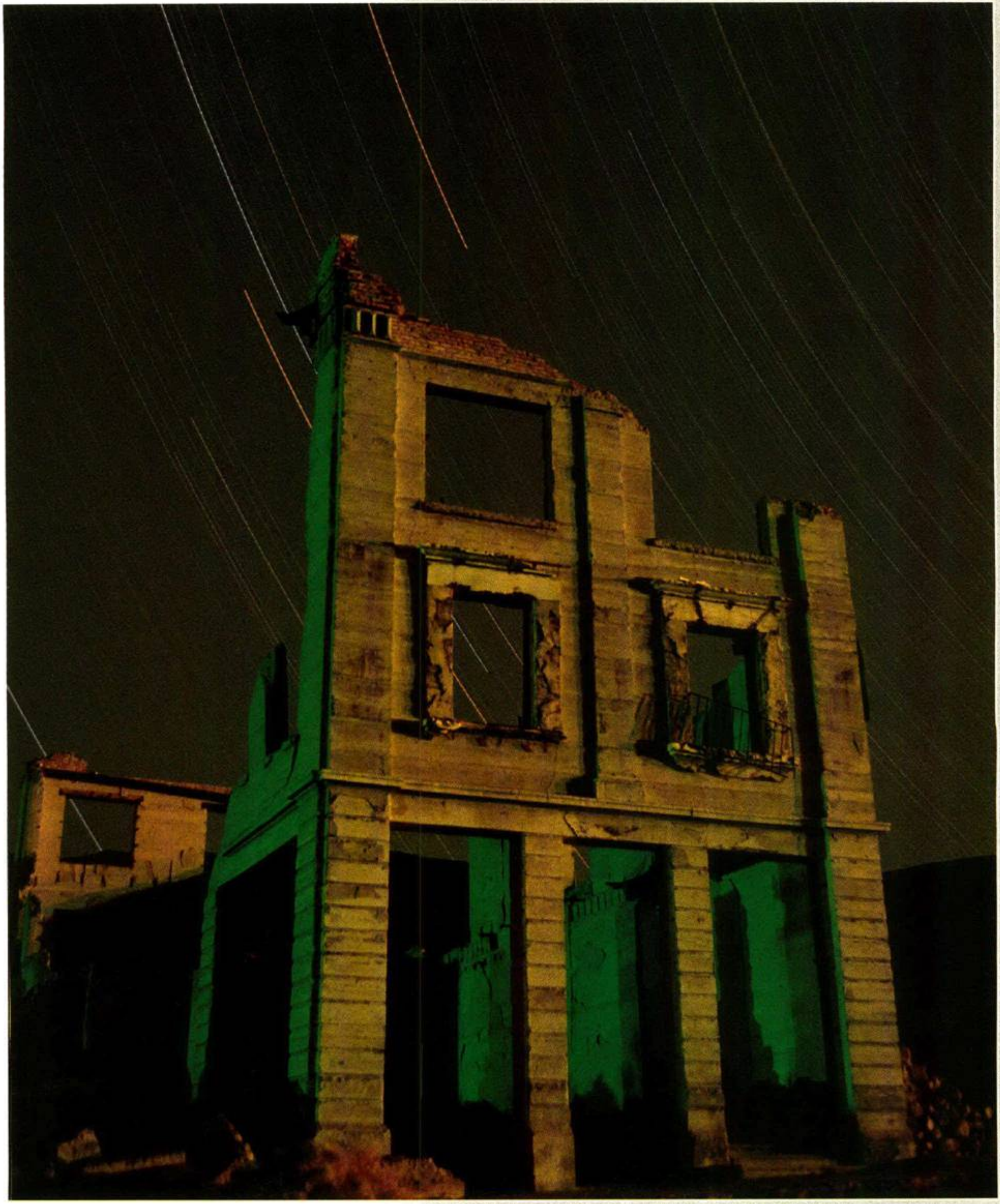

Star Trails over Ryhocite, Nevada

Joshua Vaughan

(35mm f/2 lens, Fujicolor 100 film, 4-hour exposure with ambient streetlight)

Star trail photos always gain an added dimension when terrestrial objects are framed in the foreground. In this case, nearby streetlights, the bane of most amateur astronomers, are put to good use. A hand-held red (or white) flashlight or a photoflash also works well to "paint" a scene.

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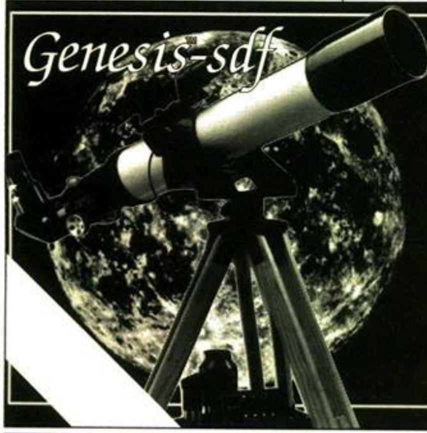

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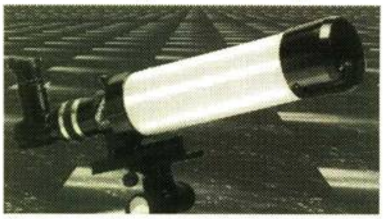

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Pronto photograph of Comet Hyakutake, by William Yang of Taiwan

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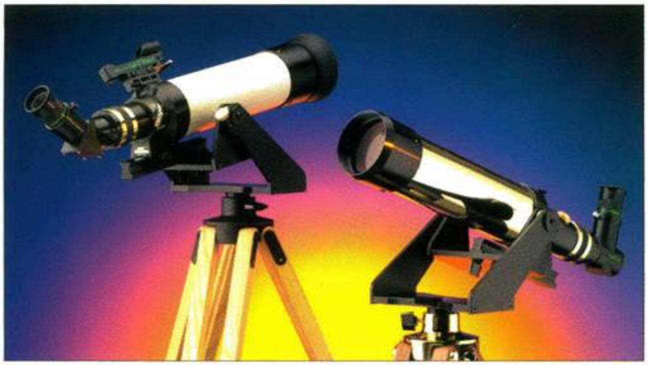

Ranger

	Ranger	**Pronto**
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Power Range:	12x - over 200x	9x - over 200x
Visual Field:	3.3°	5.5°
Photo Field:	5.2° 35mm film diag.	Same
Aperture:	70mm	Same
Focal Length:	480mm	Same
Focal Ratio:	f/6.8	Same
Focus Type:	1¼", 2 Stage with Helical	2" Rack & Pinion
Dew Shield:	Available	Captive, Sliding
Mounting:	¼-20 Balance Bar	¼-20 Mount Ring
Carry Bag:	Available	Custom Padded
Choices:	1¼" Mirror Diag., 1¼" 45°, or Porro Prisms	2" or 1¼" Mirror Diags., 1¼" 45°, or Porro Prisms
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